MRI Evaluation of Patients with Diffuse Axonal Injury and Assessment of Factors Affecting Outcome in These Patients

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ABSTRACT

Introduction: Aim of present study is to evaluate the role of MRI in Diffuse Axonal Injury Cases and to assess various factors affecting the outcome in these cases.
Material and methods: Present study was carried out on 35 cases of diffuse axonal injury in Neurosurgery department of Medical College Hospital, Gwalior from July 2006 to March 2008. A subgroup of patients with moderate and severe head injury and discrepancy between the apparently normal CT scan findings and their neurologic status were studied with MRI. The outcomes of these cases were evaluated at third month of injury by using Glasgow Outcome Scale (GOS).**Results:** Most of patients were of vegetative state in all age group and most died were of age group 31-40 years. Determination of statistically significant difference was not noted with age and gender. There was significant correlation between pupillary abnormality and outcome. There was a good correlation between imaging finding and outcome in DAI patients.
Conclusions: MRI is found to superior to CT scan for diagnosis and predication of diffuse axonal injury cases. Callosum injuries on MRI scan are not necessarily a poor prognostic sign. Outcome of DAI is correlated with MRI staging. Prognosis worsens with higher grades of DAI.

KeyWords: Diffuse Axonal Injury, Outcome, Prognosis, CT Scan, MRI.

INTRODUCTION

Diffuse Axonal Injury (DAI) is most common type of primary lesion in closed head injury patients and its sequelae have unfavorable outcome.[1,2] Many authors have reported Magnetic Resonance Imaging (MRI) advantage over computed tomographic (CT) scanning in the visualization of traumatic brain lesions.[3-5] Until recently, only largest and hemorrhagic brain lesions were seen with CT scanning.[3]

MRI has been found more sensitive in detection and classification of these brain lesions.[2,3] MRI can underestimate the true extent of DAI lesions. New MRI techniques like magnetization transfer imaging[6,7] spectroscopy[8,9] and diffusion weighted imaging[10] have been found to show axonal structural changes not seen on T2-weighted images.

Wide acceptance of MRI in diagnosis of DAI has been limited due to higher expense, lesser availability, longer examination time, difficulty in monitoring the patients and lower conspicuity of hyperacute hematomas. There are few publications showing clinical significance of identifying DAI lesions with MRI.[11-12]

Study done by Cooper et al.[13] shows that by 3 months, 80% of patients who suffer mild DAI are in the good or moderate disability categories, 5% survive in a more impaired state and 15% die usually from secondary infections or from associated extracranial injuries. In moderate DAI, 40% of the patients have attained a good recovery, one fifth has improved to a moderate disability status and 25% have died. Severe DAI is associated with significant anatomic disruption and half of these patients die. Few patients recover, less than 15% make a good recovery. About 10% of patients suffering severe DAI remain in a vegetative state.

The prognostic factors involved in patients with DAI have been variable including age, sex, initial GCS, abnormal pupillary finding, abnormal motor response, CT scan finding, associated hypotension or hypoxia, seizure, hypothalamic injury sign and associated injuries. Therefore aim of present study is to evaluate the role of MRI in Diffuse Axonal Injury Cases and to assess various factors affecting the outcome in these cases.

MATERIAL AND METHODS

Present study was carried out in Neurosurgery department of Medical College Hospital, Gwalior from July 2006 to March 2008 on thirty five cases of diffuse axonal injury. A subgroup of patients with moderate and severe head injury and discrepancy between the apparently normal CT scan findings and their neurologic status were studied with MRI. Inclusion criteria for the study were closed traumatic brain injury, GCS score<12 and CT scan criteria's for DAI. Exclusion criteria were penetrating TBI, Prolonged hypotension, hypoxia etc.

Detailed history, particulars of patients (name, age, sex, date of admission & time of injury), details of mode of injury were recorded. History of unconsciousness, vomiting, ENT bleed, seizures, weakness etc were taken. General physical and neurological examination was done. Patient was also examined for scalp injury, black eye, bleeding for nose and

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CSF leak.

The management of all of these patients with head injuries was performed according to the standardized protocol and CT scan was done. Any discrepancy between the apparently normal CT scan findings and their neurologic statuses were studied with MRI.

The outcomes of these cases were evaluated at third month of injury by using Glasgow Outcome Scale (GOS). With the help of the scale, patients were divided into 2 separate subgroups. These subgroups were evaluated separately. Good Recovery (GR), Moderate Disability (MD) and Severe Disability (SD) designated the first group while persistent vegetative state (PVS) and Death (D) constituted the second group.

RESULTS

Table 1 shows that when evaluating the relationship between outcome and age, it was seen that most of patients were of vegetative state in all age group. Most of the patients who died were of age group 31-40 years. Determination of statistically significant difference was not noted.

Comparison between genders for the difference of outcome revealed no correlation between sex and outcome. Determination of statistically significant difference was not noted. (Table 2)

In present study, 33% of mortality rate was observed with GCS score 5 or less. There was 13% mortality rate in patients with GCS score from 6 to 8. There was no mortality in GCS> 9 group. Thus there is significant correlation between GCS and outcome. Determination of statistically significant difference was not possible. (Table 3)

There were 28 patients who had normal sized symmetrical pupil. Out of these, 4 patients failed to recover consciousness. There was 5 patients who showed unequal size pupil, 4 (80%) of these failed to recover consciousness. There were 2 patients who showed bilateral pupillary dilatation, none of these recovered consciousness. Thus there is significant correlation between pupillary abnormality and outcome. Determination of statistically significant difference was also noted. (Table 4)

In the present study, 5 out of 21 patients who had abnormal motor responses, failed to show any recovery in consciousness level. 13 patients out of 14 patients having normal motor response had gained consciousness. It showed a good correlation between motor response and outcome in DAI patients. But these did not showed statistically significant correlation. (Table 5)

In present study, stage-I of DAI patients showed good outcome. Most of the patients of moderate disability, severe disability and vegetative stage were of stage-II and stage-III. It showed a good correlation between imaging finding and outcome in DAI patients. But determination of statistically significant difference was not possible. (Table 6)

DISCUSSION

In present study, most of the patients who had normal sized symmetric pupil recovered consciousness and most of patients who had unequal sized pupil (Anisocoria) failed to recover consciousness. None of the patient showed recovery that had bilateral pupillary dilatation. In study by sung et al.[14] non-recovery rate of patients having normal sized pupil was 24%, anisocoric pupil was 83% and bilateral pupil dilatation was 100%. Thus pupillary findings had significant influence on outcome of DAI. These pupillary findings are suggestive of the high incidence of brainstem involvement in these cases.

In present study, 14 patients had normal motor response and 13 of which (92.86%) had recovered consciousness. 21 patients showed abnormal motor response and 16 of which (76.2%) recovered consciousness. In study by Sung et al.[14] patients who had normal motor responses had 74% of recovery rate, whereas those with abnormal motor response showed only 21% of recovery rate. Thus motor response to stimuli had been found to have significant influence on outcome of DAI. Abnormal motor response to stimuli is related to worse prognosis. (Levi et al.[15])

In present study, petechial haemorrhage at grey-white matter junction were seen in 9 patients on CT scan while MRI showed such petechial haemorrhage at grey white matter junction in 33 patients. Petechial haemorrhages at grey white matter junction were located mainly in the frontal and temporal lobes. The white matter of the superior frontal gyrus was most often affected. (Scheid R et al.[16]) Periventricular petechial haemorrhages were present in 2 patients on CT scan while MRI displaced such periventricular petechial haemorrhages in 5 patients. Brain stem petechial haemorrhage was present only in 2 patients on CT scan but 14 patients showed such brain stem petechial haemorrhage on MRI. Involvement of the brainstem was observed, mostly of the superior cerebellar peduncle. (Scheid R et al.[16]) Among the radiological characteristics associated to DAI patients, the most clearly related is intra-ventricular haemorrhage.[17]

In present study, 3 patients had intraventricular haemorrhage on CT scan but 4 patients showed IVH on MRI. All of them were associated with corpus callosum injury. Gentry et al.[3] found a high incidence of IVH in association with callosum injury which is explained by rich vascularity of corpus callosum. The shearing forces that are responsible for callosal injury easily tear the subependymal plexus of veins that normally lie along the undersurface of corpus callosum and produce IVH.

CT scan of 19 patients demonstrated no lesions. However, the MRI of these 19 patients with no lesion on CT scans revealed findings of DAI. Out of these 19 patients, 5 patients had stage-I MRI findings, 8 patients showed stage-II MRI findings and 6 patients displayed stage-III MRI findings. As a matter of fact this study also shows that MRI scans of these DAI patients reveal both haemorrhagic and non-haemorrhagic lesions. These lesions could not be visualized by CT scan and this is particularly true for non-haemorrhagic type. MRI plays an important role in patients with a negative CT scan who are neurologically impaired and in whom DAI is a diagnostic probability (Gentry et al.[3], Evans et al[18]).

In present study, no patient showed corpus callosum injury on CT scan while MRI revealed corpus callosum lesions in 28 patients, most of which was present in splenium (93.1%). Traumatic lesions of the corpus callosum are frequently seen in moderate and severe head injuries. Most of the lesions are non-haemorrhagic and localized in splenium.[19]

Callosal DAI lesions may be quite large and may occasionally involve the entire corpus callosum. Even though callosal DAI lesions tend to be much larger than lobar DAI, they can also be difficult to detect on initial CT scan[3]. Callosal injuries on MRI scan are not necessarily a poor prognostic finding. [20]

In present study, no patient showed SAH on CT scan while 9 patients display SAH on MRI. SAH was present in all grading of DAI. Series of DAI patients of Paterakis et al.[1] confirms the same. In present study, 11 out of 35 patients had been found to have forniceal injury. Mean GCS of these patients were 5.42. Outcome of these patients were as moderate disability (2), severe disability (3), vegetative state (3) and expired (3). Thus findings of forniceal injury had been found to have poor outcome in these cases. In study by Blumbergs et al[11] fornices were affected in 76% of DAI cases. Involvement of fornix was seen in many cases which is usually not noticed. Memory disorders accompany damage to either the hippocampus or fornix.[22, 23] Trauma results in fornix and hippocampal atrophy, with degree of atrophy related to severity of injury. The MR imaging appearance of DAI lesions depends on several factors, including the time since injury, the presence of haemorrhage or blood breakdown products and the type of sequence used.

Prognosis & outcome

The prognostic factors involved in patients with DAI have been variable including age, sex, initial GCS, abnormal pupillary finding, abnormal motor response, CT scan finding, associated hypotension or hypoxia, seizure, hypothalamic injury sign and associated injuries.

Age clearly influences the clinical course with regard to both mortality rate and quality of survival. Although, there was no statistical significant correlation between age groups and outcome, there was strong tendency for poor prognosis after 40 year. DAI lesions in adult were usually haemorrhagic hence had poor prognosis.[1,24] 50% of male had no recovery and 20% of female had no recovery in present study but difference of outcome was not statistically significant. Hence comparison between genders for the difference of outcome revealed no correlation between sex and outcome.

33 of 35 patients were of GCS <8 in present study but only 16 patients belong to non-recovery group. This indicates lack of correlation of GCS with Glassgow outcome score. In present series, the fact that GCS itself is not a sufficient outcome predictor is reported by Levi at al.[15]

Eisenberg et al.[25] emphasized that head injury patients with associated hypoxia or hypotension are expected to have the worst outcome and since damaged brain is more vulnerable to hypoxia or hypotension combined with either or both conditions would be associated with poorer outcome. In present study, most of stage-I DAI patient had good outcome, most of stage-II and stage-III of DAI patient had poor outcome. This is also observed in all above mentioned series. Most of the DAI patients show poor prognosis and Glassgow

Age	GR	MD	SD	VS	Death
0-10	00	02	00	01	00
11-20	04	00	02	02	01
21-30	02	05	01	03	01
31-40	01	01	01	03	04
>40	00	00	00	01	00
Total	07	08	04	10	06
P> 0.05 (0.193)					

Table-1: Comparison of Outcome according to Age Group

Gender	GR	MD	SD	VS	Death
Male	06	06	03	09	06
Female	01	02	01	01	00
Total	07	08	04	10	06
P> 0.05 (0.68)					

Table-2: Comparison of Outcome according to Gender of patients

GCS	GR	MD	SD	VS	Death
>9	01	01	00	00	00
8	01	02	00	00	00
7	04	01	02	01	01
6	01	04	01	03	02
5	00	00	01	01	01
4	00	00	00	05	02
P> 0.05 (0.16)					

Table-3: GCS grading correlation with clinical outcome of patients

Pupillary Status	Recovery		Non-recovery	
	No.	%	No.	%
Normal Size	24	85.71	04	14.29
Anisocoria	01	20	04	80
Bilateral pupil dilatation	00	0	02	100
P< 0.05 (0.0079)				

Table-4: Correlation between pupillary abnormalities and outcome

Motor Response	Recovery		Non-recovery	
	No.	%	No.	%
Normal (M5,M6)	13	92.86	01	7.14
Abnormal (M4 & below)	16	76.2	05	23.8
P> 0.05 (0.19)				

Table-5: Correlation between abnormal motor response and outcome

DAI Stage	GR	MD	SD	VS	Death
1	02	02	00	02	00
2	04	05	02	02	04
3	01	03	02	06	02
P> 0.05 (0.49)					

Table-6: Imaging findings correlated with the clinical outcome of patients outcome scale was observed to worsen with higher grades of DAI.[1]

The DAI stages are located sequentially deeper with increasing severity of trauma[26]. This was shown in present study as well. Combination of lesions in corpus callosum and brainstem is a combination of lesions in the corpus callosum and the dorsolateral upper brainstem is a frequent MR imaging feature in patients in post-traumatic vegetative states associated with DAI. Injury to the corpus callosum is an indicator of other possible midline lesions, particularly in the brainstem, which may be responsible for the unconsciousness.

Patients with DAI and concomitant lesions have worst prognosis than do the patient with DAI alone.[27] Mild and moderate DAI lesions are not haemorrhagic and presence of haemorrhage in DAI type lesion is a poor prognostic sign.[28] Improved MRI technique indicates that the proportion of haemorrhagic DAI lesions is greater than previously suspected.[2]

Distinct from other types of head injury patient with the diagnosis of DAI have normal ICP and CPP levels but secondary factors such as hypoxia, hypercapnia and hypotension may lead to elevation in ICPs following edema formation[29]

This study had a number of limitations. Firstly, the time of CT and MR imaging was variable. Secondly, patients with the most severe degree of head injury were likely not to be included because these patients are not stable enough to undergo CT and MR imaging. Thirdly, many factors such as infection, hypoxemia or hypotension may be present before or after neurologic imaging and may influence clinical outcome in traumatic brain injury. Finally drawback is the limited number of patients which does not allow a separate analysis of the influence of concomitant lesions such as contusions and SAH, on the final outcome.

CONCLUSION

MRI is found to superior to CT scan for diagnosis and predication of diffuse axonal injury cases. Determination of statistically significant difference was not noted with age and gender. There was significant correlation between pupillary abnormality and outcome. DAI stages are located sequentially deeper with increasing severity of trauma. Corpus callosum lesions are located mainly in the posterior body and splenium. Callosum injuries on MRI scan are not necessarily a poor prognostic sign. Outcome of DAI is correlated with MRI staging. Prognosis worsens with higher grades of DAI.

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