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Clinico Radiological Study of Diffuse Axonal Injury and Outcome Analysis After Management

Dr. Srikrishna Majhi,
MCH, Associate Professor, Department of Neurosurgery, Kolkata Medical College & Hospital, Kolkata, West Bengal – 700073. (Corresponding Author)
Dr. Sandip Pal,
MCH, Associate Professor, Department of Neurosurgery, Kolkata Medical College & Hospital, Kolkata, West Bengal – 700073.
Professor K. S. Chakraborty,
MCH, Department of Neurosurgery, Professor & Head of the department, Kolkata Medical College & Hospital, Kolkata & Head of the department, West Bengal – 700073.
Corresponding Author
Dr. Srikrishna Majhi,
MCH, Associate Professor, Department of Neurosurgery, Kolkata Medical College & Hospital, Kolkata, West Bengal – 700073.
Address - 98/1 S. N. N Ganguly Road, P.O.: Santragachhi, P.S.: Chatterjee haat, Howrah, West Bengal, 711104

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KEYWORDS
Diffuse axonal injury, Radiological, Glasgow Coma Scale (GCS) and MRI findings.

ABSTRACT

Background: The examination of patients' of diffuse axonal injury (DAI) on the basis of clinical profile and radiological results in relation to their prognosis.

Methods: 33 patients of closed head injury and discrepancy between apparently normal computed tomographic scan findings and their neurologic statuses were studied with MRI. Among them, 22 were found to suffer from DAI-type lesions. According to the Glasgow Coma Scale (GCS), 18 patients suffered from severe head injury (CCS score <8) and 4 patients had moderate head injury (GCS score of 9-12).

Results: Road traffic accident is main cause of head injury. All patients with GCS 9 have good recovery. Patients who presented with CCS 4,5 had worse outcome in comparison to those with admission GCS 6 to 8.All patients with Grade 1 DAI had good recovery. Outcome was worse in the group with Grade 3 DAI when compared with Grade 1 and 2.

Conclusions: MRI is more sensitive compared with computed tomography in the detection of traumatic brain lesions. Evaluation of the Glasgow Coma Score and MRI findings on admission led to an improved ability to forecast outcomes.

INTRODUCTION

Diffuse axonal injury (DAI) is one of the most common and devastating types of traumatic brain injury [(1)], meaning that damage occurs over a more widespread area than in focal brain injury. DAI, which refers to extensive lesions in white matter tracts, is one of the major causes of unconsciousness and persistent vegetative state after head trauma [(2)]. "It occurs in about half of all cases of severe head trauma and also occurs in moderate and mild brain injury. The outcome of severe DAI is frequently coma, with over 90% of patients with severe DAI never regaining consciousness [(2, 3)]. Those who do wake up often remain significantly impaired [(4)]. There are three stages of involvement according to the anatomic location of the lesions,

1. Stage I- This involves the parasagittal regions of thefrontal lobes, the periventricular temporal lobes, and lesslikely, the parietal and occipital lobes, internal capsule.
2. Stage II-This involves corpus callosum in addition tothe white matter areas of staged.
3. Stage III- This involves areas associated with stage II with addition of brainstem involvement.

Classically. DAI considered a primary type injury, with damage occurring at time of accident. Another

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component of injury comprises the secondary factors, since axons are injured, secondary swelling occurs. DAI is suggested in any patient who demonstrates clinical symptoms disproportionate to his or her CT scan findings. The chance that a patient will remain in a persistent vegetative state is greater when lesions are in supratentorial white matter, corpus callosum and corona radiata. The prognosis also worsens as number of lesions increases.

Based on clinical criteria, three levels of DAI are recognized:

1) Mild DAI coma lasting six to twenty-four hours. 2) Moderate DAI coma with no decerebrate posturing that lasts longer than 24 hours 3) Severe DAI - coma lasting longer than 24 hours with decerebrate posturing or flaccidity.

Among patient proven to have DAI, 50- 80% have normal CT scan upon presentation. Small petechial haemorrhages, located at the grey-white matter junction, as well as in corpus callosum and brainstem, are characteristic of CT scan findings in the acute settings. Magnetic Resonance imaging is the preferred examination for diagnosis of DAI particularly with gradient-echo sequence [11, 12]. Gradient-echo imaging particularly sensitive for hemorrhagic lesions after DAI, whereas diffusion-weighted (DW) sequences are more effective in identifying shear injuries. Gradient- echo demonstrate signal abnormality in areas that appear normal in T1-weighted and T- weighted spin-echo sequences. The most common MRI finding is the presence of multifocal areas of abnormal signal (bright on T2 weighted images) in the white matter in the temporal or parietal corticomedullary junction or in the splenium of the corpus callosum. MRI will likely play a larger role in predicting outcome and directing care for patients with DAI.

PATIENTS AND METHODS

This was a prospective observational study of severe traumatic brain injury patients admitted with diffuse axonal injury without surgical lesion to Neurosurgical Unit, ICU, Neuro Medicine, General Medicine, Surgery and Orthopedic Departments in Kolkata Medical College & Hospital, Kolkata. The study was conducted between 21st August 2022 and 30th June 2023 with 315 closed head injury patients who underwent clinical and computed tomographic (CT) examination. 33 patients with closed head injury and discrepancy between the apparently normal CT scan findings and their neurologic statuses were studied with MRI. Among them, 22 patient who were found to suffer from DAI-type lesions were selected for study. According to the Glasgow Coma Scale (GCS), 18 patients had severe head injury (GCS scored 8) and 4 patients had moderate head injury (GCS score of 9-12).MRI scan was obtained used to diagnose DAI lesions in the corpus callosum and the dorsolateral Midbrain and upper pons. NO Contrast was administered. According to GOS, the result was evaluated, and a minimum follow-up of six months was required (Table 4). Three groups of patients were created based on the literature-described staging. Patients with injuries limited to the frontal and temporal lobes' white matter were included in stage 1. Patients in Stage 2 had lesions in the posterior portion of the corpus callosum and the lobar white matter. Patients with lesions in the upper pons and dorsolateral parts of the midbrain were included in stage 3.

Table 1: Age Distribution

Age (In Year)	No of Patients	Percentage
0-12 Years	2	9%
15-30 Year	14	64%
31-45	3	14%
46-60	2	9%
Above 60	1	4%

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Table 2: Sex Distribution

Sex	No of Patients	Percentage
Male	18	82%
Female	4	18%

Table 3: Mode of Injury

Mode of Injury	No of Patients	Percentage
RTA	16	74%
Fail from height	4	18%
Domestic fall	-	-
Assault	1	4%
Industrial Agricultural injury	1	4%

Table 4: GCS Grading Correlation with the Clinical Outcome of the Patients

CGS	GR	MD	SD	VS	D
9	4	-	-	-	-
8	2	1	-	-	-
7	2	1	1	-	-
6	1	2	1	1	-
5	1	1	-	1	1
4	-	-	-	1	1

Table 4: GCS Grading Correlation with the Clinical Outcome of the Patients DAI, diffuse axonal injuries GR, good recovery; MD, moderate disability: SD, severe disability, VS, vegetative state; D, Death.

DAI Stage	GR	MD	SD	VS	D
1	6	-	-	-	-
2	3	2	1	1	-
3	1	3	1	2	2

There was a statistical study done with between various stages and between patients. With and without hemorrhagic DAI. A separate analysis with and Yates correction was carried out once patients were divided into groups based on their level of recovery disability against patients with severe disability and vegetative state.

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Figure: 1. MRI Brain shows hpertense in left cerebellar peduncle.... State III DAl.

Figure: 2. MRI Brain shows hpertense in left Patietal region. Stage. .. State III DAI

RESULTS

Main exposed age group to head injury is young age and working group 15-30 years (64%) and 31-45 years (14%) as depicted in Table 1. Males (82%) are more vulnerable to head injury as he is main working population. Road traffic accident (74%) is main cause of head injury, so with diffuse axonal injury as shown in Table 3.

Clinical correlation with GCS and clinical outcome shown in Table 4.All patients with GCS 9 have good recovery. Two patients (66%) with GCS B had good recovery and one patient (33%) had moderate disability. Two patients (50%) with CCS 7 had good recovery. one patient: 25%) had moderate disability and one patient (25%) had severe disability. With GCS 6 one patient 20%) had good recovery. Patient (40) had moderate disability. One patient 20%) had severe disability and one patient (20%) persist in vegetative state. With GCS 5.one patient (20%) had well! recovery, one patient (25%) had moderate. disability, one patient (25%) persist in vegetative state and one (25%) died. GCS 4 had very poor outcome with one (50%) died and other one persist in vegetative state.

The relationship between the patients' clinical results and imaging results is shown in Table 5. Ten patients (46%) with DAI 1, DAI 2, and DAI 3 showed satisfactory GOS results, according to recovery. Five patients (23%) three with DAI 3 and two with DAI 2, showed moderate disability Two patients (9%), one with DAI 3 and one with DAI 2, showed severe disability. Three- patients (13%), one with DAI 2 and two with DAI 2persist in vegetative state. Two patients (9%) die having grade DAI 3.

A statistical study revealed a significant difference ($p=0.013$) among the patients with varying DAI stages.

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Following the separation of patients with moderate disability and excellent recovery from those with severe disability, a further statistical analysis was conducted in the latter group, and vegetative state with Yates correction showed a significant difference in outcome ($p = 0.012$).

DISCUSSION

Traumatic diffuse axonal injury was first described by Strich [5] in 1956 as "diffuse degeneration of white matter following severe head injury. Later she described shearing of nerve fibres as a cause of brain damage due to head injury [6].

In 1981 Adams et al. described the pathological hallmarks of this condition [7]. In 1943, Holbourn published the first description of the pathophysiology of DAI [8], led to understanding that shear injury is due to rotational forces, McCormick [9] in 1996 described three classic" lesions which characteristic severe traumatic diffuse axonal injury as Reactive axonal retraction" balls, Haemorrhagic necrosis in dorsolateral quadrant of the rostral brainstem, Haemorrhagic necrosis in the corpus callosum. These were earlier described as characteristic pathological lesions in 1981 by Adams et al [7]. The axonal swelling are the microscopic hallmarks of diffuse axonal injury. Typically, patients with DAI present with severe impairment of consciousness immediately after the injury [13]. "A strong inverse relationship exists between the quantity of lesions found and the long-term GOS score. Consequently, it is crucial from a therapeutic standpoint to forecast the outcome by the most sensitive and least invasive imaging method. According to autopsy investigations, fatal head injuries are associated with an 80% to 100% incidence of DAI. As a result, MRI is crucial for assessing neurologically compromised patients whose CT scan came out negative and for whom DAI is a likely diagnosis [11,12,13,14]. Few studies exist on the correlation between imaging and outcome [15, 16]. The reason for the rise in DAI 2 and DAI 3 cases compared to DAI 1 is that patients were chosen for MRI because their neurologic state and the results of their CT scan were incompatible.

Patients who presented with GCS 4, 5 had worse outcome in comparison to those with admission GCS 6 to 8 ($p=0.001$). Andrews [10] in 1998 found similar outcome results in patients with DAI. The component of GCS which had significant impact on outcome was motor response. Patients presented with abnormal motor score had worse outcome than those with normal motor score ($p = 0.01$).

Outcome was worse in the group with Grade 3 DAI when compared with Grade 1 and 2.

CONCLUSIONS

A specific treatment plan is needed for: patients with diffuse axonal injury. Evaluation of the Glasgow Coma Score and computed tomographic findings with MRI on admission led to an improved ability to forecast outcomes. The depressed consciousness resulting in the very poor state of responsiveness may be just due to diffuse injury to the brain, which may recovered better than other parenchymal brain injury.

The limitations of our study are:

1. Short follow-up periods which may not reflect the long term outcome.
2. Usage of simple Glasgow Outcome Score(GOS) for outcome assessment,did not assess different type and degree of disabilities.

Future study should be done to overcome these limitations.

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