



ORIGINAL RESEARCH PAPER

Neurosurgery

THE HIDDEN AFTERMATH: DECIPHERING THE EPIDEMIOLOGY OF DIFFUSE AXONAL INJURY

**KEY WORDS:** Diffuse Axonal Injury, Head Injury, Silent Epiemic, MRI, Coma

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| ABSTRACT | <p><b>BACKGROUND</b> Traumatic brain injury (TBI) is a major medical, social and economic challenge as it is associated with high mortality, and long-term disabilities and is referred to as a silent epidemic. Diffuse axonal injury (DAI) is one of the most severe types of primary traumatic brain injury. The microscopic nature of the axonal swelling makes DAI nearly invisible to conventional neuroimaging approaches, such as CT and conventional MRI. Newer sequences of MRI that can reveal the sites of microbleed are Gradient Echo, Flair, DWI and SWI and Diffusion Tensor Imaging (DTI). <b>METHODS</b> This prospective study was conducted on patients with Diffuse Axonal Injury following Traumatic Brain Injury, admitted in the Department of Neurosurgery IMS BHU Varanasi, from January 2023 to December 2023 which included a total of 91 patients. <b>RESULTS</b> We found that out of 734 TBI cases admitted incidence of DAI was 12 %, most common age group to be affected being 20 -30 years, Male : Female ratio being 5.06:1., the mechanism of trauma with RTA being most common group with 75 cases (82.4). Among RTA Four wheeler injuries being 31 cases (34.1%). Brainstem DAI was the most commonly involved with in 71 cases (78%) and Grade 1 DAI with Hemispheric involvement was seen in 12 cases (13.2%), Grade 2 with involvement of Corpus Callosum in 8 cases (8.8%), mortality rate was 13.2% <b>CONCLUSION</b> The current study demonstrated that lesions in the brainstem were especially associated with low GCS scores.</p> |
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| <p><b>BACKGROUND</b></p> <p>Traumatic brain injury" refers to an alteration in brain function or other evidence of brain pathology caused by external force<sup>1</sup> and traditionally is classified as mild, moderate, and severe based on the Glasgow Coma Scale (GCS).<sup>2</sup> TBI with GCS score of 13 or more is classified as mild, 9 to 12 as moderate, and 8 and lower as severe.<sup>3</sup></p> <p>Diffuse axonal injury (DAI) is a condition characterize as multiple, scattered, small hemorrhagic, and/or nonhemorrhagic lesions, alongside brain swelling, in a more confined white matter distribution on imaging studies, together with impaired axoplasmic transport, axonal swelling, and disconnection with more than 3 such foci present on imaging studies. In the past, DAI (diffuse axonal injury) was defined as prolonged (&gt; 6 h) loss of consciousness (LOC), without a visible mass lesion<sup>4</sup>. The microscopic nature of the axonal swelling makes DAI nearly invisible to conventional neuroimaging approaches, such as CT and conventional MRI.<sup>5</sup> MRI evolved as the imaging modality of choice to detect even nonhemorrhagic tissue damages related to DAI<sup>6-7</sup></p> | <p>Neurosurgery at Institute of Medical Science, Banaras Hindu University.</p> <p><b>INCLUSION CRITERIA</b></p> <ol style="list-style-type: none"> <li>1. All patients with recent closed head injury and CT Head revealing features corresponding to DAI and or no definite bleed</li> <li>2. Age above 12 years and less than equal 60 years.</li> </ol> <p><b>EXCLUSION CRITERIA</b></p> <ol style="list-style-type: none"> <li>1. Age less than 12 years or more than 60 years.</li> <li>2. Patients undergoing surgical management for traumatic brain Injury.</li> <li>3. Patients who have definite hemorrhage in CT Head (Contusion, Sdh, Sah, Edh, Ich, Ivh)</li> <li>4. Patients with polytrauma with associated injuries</li> <li>5. Patients suffering from Primary Neurocognitive Diseases</li> <li>6. Age less than 12 years and more than 60 years</li> <li>7. Pregnancy</li> </ol> <p><b>STATISTICAL ANALYSIS</b></p> <p>Statistical Analysis was carried out using Statistical Package of Social Sciences (SPSS) software 20.0. Differences in proportions or frequencies between basic and clinical field subjects were analysed by chi square test. Intergroup comparison were analysed by Independent t-test and One - way ANOVA test was used to compare mean values.</p> |
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MATERIAL AND METHODS :

This prospective study was conducted on patients with Diffuse Axonal Injury following Traumatic Brain Injury, admitted in the Department of Neurosurgery IMS BHU Varanasi, from January 2023 to December 2023. Informed consent was taken from the immediate relatives (first degree). All Patients underwent baseline NCCT Head followed by MRI Brain with T1/T2 weighted images with DWI, GRE and FLAIR sequences and or DTI on Day 1 of admission and were followed up by repeat investigation as and when required. The patients were clinically evaluated on a daily basis till their discharge or demise. Upon finding the location of injury the patients were divided into different grades of DAI and different parameters were compared till hospital stay and follow up upto 6 months. A total of 91 patients of DAI were included in the study from a total of 734 admitted Traumatic head injury patients after satisfying the Inclusion criteria and proper evaluation with different imaging modalities and appropriate follow up was done in the Department of

RESULTS AND OBSERVATIONS

Table 1: Epidemiological data

| Description         | Frequency     |                |
|---------------------|---------------|----------------|
| Total TBI Cases     | 734           |                |
| DAI Cases           | 91            |                |
| Age groups in Years | Frequency (n) | Percentage (%) |
| 12-20               | 30            | 32.96703       |
| 20-30               | 35            | 38.46154       |
| 31-40               | 20            | 21.97802       |
| 41-50               | 4             | 4.395604       |
| 51-60               | 2             | 2.197802       |
| Total               | 91            | 100            |
| Gender              | Frequency (n) | Percentage (%) |

|                   |               |                |
|-------------------|---------------|----------------|
| Female            | 15            | 16.5           |
| Male              | 76            | 83.5           |
| Total             | 91            | 100.0          |
| GCS at admission  | Frequency (n) | Percentage (%) |
| <8                | 54            | 59.34066       |
| 9-12              | 37            | 40.65934       |
| 13-15             | 0             | 0              |
| Total             | 91            | 100            |
| Social background | Frequency (n) | Percentage (%) |
| Rural             | 69            | 75.8           |
| Urban             | 22            | 24.2           |
| Lesion in CT Head | Frequency     | Percentage     |
| Yes               | 34            | 37.3           |
| No                | 57            | 62.7           |
| Mortality         | Frequency     | Percentage     |
| No                | 79            | 86.8           |
| Yes               | 12            | 13.2           |

Table 1 Shows that incidence of DAI was 12.39%,most common age group of presentation was 20-30 years age group,males affected more ,75.8% patients were from rural background ,most cases had GCS less than 8 at admission ,37.3% lesions were detected on CT head and mortality rate was 13.2%

**Table 2: Mechanism of Trauma**

| Mechanism of Trauma | Frequency (n) | Percentage (%) |
|---------------------|---------------|----------------|
| Fall from height    | 16            | 17.6           |
| RTA (n=75; 82.4%)   |               |                |
| Four wheeler        | 31            | 34.1           |
| Pedestrian          | 5             | 5.5            |
| Two wheeler         | 39            | 42.9           |
| Total               | 91            | 100.0          |

Table 2 Shows the mechanism of trauma with RTA being most common group with 75 cases (82.4%) followed by fall from height 16 (17.6%) cases. Among RTA Four wheeler injuries being 31 cases (34.1%) ,Two Wheeler cases being 39 (42.9%) and Pedestrian 5 cases (5.5%)

**Table 3: Use of Helmet among RTA Cases.**

| Helmet | Frequency (n) | Percentage (%) |
|--------|---------------|----------------|
| No     | 64            | 85.33          |
| Yes    | 11            | 14.67          |
| Total  | 75            | 100.0          |

Table 3 Showing that 11 cases used helmet (14.67%) out of 75 Cases of RTA

**Table 4: Under influence of Alcohol at the time of injury**

| Under influence | Frequency (n) | Percentage (%) |
|-----------------|---------------|----------------|
| Alcohol         | 19            | 20.9           |
| No              | 72            | 79.1           |
| Total           | 91            | 100.0          |

Table 4 Shows that 20.9% patients in our study were under influence of alcohol at the time of injury. Table 5 shows that distribution of location of injury with hemispheric lesions being most common in 76 cases (83.5%) and among hemispheric lesions,Frontal lobe was most commonly involved.Basal Ganglia was involved in 6.6% cases and Thalamus in 18.7% cases.

Among lesions in Corpus Callosum body of corpus callosum being most commonly involved in 32 cases (35.2).Among Midbrain lesions,Crus Cerebri was most commonly involved in 51 cases (56.5%)

Pontine lesions were in 21 cases (23.1%) and upper pons more commonly involved than lower pons.Pons were divided into two parts; upper pons at the level of trigeminal nuclei and lower pons at the level of facial colliculi.

**Table 5: Distribution of Location of injury**

| Location of lesion                                   |              | Frequency (n) | Percentage (%) |
|------------------------------------------------------|--------------|---------------|----------------|
| Hemispheric                                          |              | 76            | 83.5           |
| Basalganglia                                         |              | 6             | 6.6            |
| Thalamus                                             |              | 17            | 18.7           |
| CORPUS CALLOSUM                                      | Body         | 32            | 35.2           |
|                                                      | Genu         | 9             | 9.9            |
|                                                      | Splenium     | 28            | 30.8           |
| MID BRAIN                                            | Tectum       | 10            | 11.0           |
|                                                      | Tegmentum    | 25            | 27.5           |
|                                                      | Crus cerebri | 51            | 56.5           |
| PONS                                                 | Upper pons   | 13            | 14.3           |
|                                                      | Lower pons   | 8             | 8.8            |
| Medulla oblangota                                    | 0            | 0             |                |
| Cerebellar peduncles                                 | 8            | 8.8           |                |
| Miscellaneous (IVH/Non hemmorhagic lobar contusions) | 11           | 12.09         |                |

**Table 6: Distribution of Grade of DAI**

| Grade DAI | Frequency (n) | Percentage (%) |
|-----------|---------------|----------------|
| 1         | 12            | 13.2           |
| 2         | 8             | 8.8            |
| 3         | 71            | 78             |
| Total     | 91            | 100.0          |

According to the location of injury on radiological investigation and presenting GCS at admission we have given a new grading system of DAI which would help to predict the prognosis the further course of management.

Table 6 Shows that Brainstem DAI was the most commonly involved with in 71 cases (78%) and

Grade 1 DAI with Hemispheric involvement was seen in 12 cases (13.2%), Grade 2 with involvement of Corpus Callosum in 8 cases (8.8%).

**Table 7.: GCS at discharge**

| GCS at discharge |          |
|------------------|----------|
| Mean             | 12.0127  |
| Median           | 12.0000  |
| SD               | 2.13934  |
| IQR; Range       | 11-14; 9 |

Table 7 shows that the mean GCS at discharge was 12.01,median GCS being 12.00,SD 2.139,IQR;Range 11-14;9.

## DISCUSSION

In our study we found that out of 734 TBI cases admitted in the department of Neurosurgery,IMS,BHU,91 cases had DAI (12 % ).Dheeraj Godhra et al in 2023 found the incidence of DAI to be 13.45%<sup>8</sup>

The most common age group to be affected being 20 -30 years with mean age being 25.47 years with SD 9.91 ,median age being 23.00 and IQR range 18-31;44.

Al Ali Bshabashe in 2023 studied 33 DAI patients whose ages ranged from 15 to 60 years (15-25 years: [17 cases = 52%], 26-36 years: [11 cases = 33%], above 36 years: [5 cases = 15%])<sup>9</sup> In our study , the Gender distribution with Male 76 (83.5 %)

and females being (16.5%) with Male : Female ratio being 5.06:1. Al Ali Bshabashe in 2023 found that majority of patients being males (30 case = 91%) with 3 females (9%).<sup>1</sup>

In this study we found the mechanism of trauma with RTA

being most common group with 75 cases (82.4%) followed by fall from height 16 (17.6%) cases. Among RTA Four wheeler injuries being 31 cases (34.1%), Two Wheeler cases being 39 (42.9%) and Pedestrian 5 cases (5.5%) Dheeraj et al 2023 found in their study two wheeler injuries being 53.19% cases, four wheeler injuries being 23.4% cases, pedestrian injuries being 8.5% cases, fall from height being 14.89% cases.<sup>8</sup> The distribution of GCS at admission was 54 patients (59.34%) presented with GCS less than 8 i.e Severe Traumatic Brain Injury and 37 patients (40.65%) presented with GCS between 9-12 i.e Moderate Traumatic Brain Injury. No patient presented with GCS 13-15 at admission Dheeraj et al in 2023 found in 94 DAI patients GCS at admission with GCS less than 5 being 30.85% cases and GCS 5-8 being 69.14%<sup>8</sup>

Brainstem DAI was the most commonly involved with in 71 cases (78%) and Grade 1 DAI with Hemispheric involvement was seen in 12 cases (13.2%), Grade 2 with involvement of Corpus Callosum in 8 cases (8.8%). Faruk Javed et al in 2021 studied that in 133 cases of DAI, 44.1% cases belonged to Grade 1 Adams DAI, 36.1% Grade 2 and 22.5% Grade 3 DAI<sup>10</sup>

Dheeraj et al in 2023 in their study found Adams Grade 1 DAI in 50% cases, Grade 2 in 31.25% cases and Grade 3 in 18.75% Cases.<sup>8</sup>

NCCT head detected lesions suggestive of DAI in 37.3% cases. Dheeraj et al found that 57.4% cases could detect lesions in NCCT Head.<sup>8</sup>

We found that 12 patients (13.2%) expired during the hospital stay and all cases belonged to grade 3 DAI. Vaidyanathan R et al 2020 found the mortality rate to be 2.9% in their 6 months follow up.<sup>11</sup> Dheeraj et al 2023 found 40% mortality rate in their study of 94 cases.<sup>8</sup>

## CONCLUSION

DAI has now become a common form of traumatic brain injury. In affected patients, long-term hospitalization is necessary until consciousness is restored, and this period is associated with the many problems of ICU care. Therefore, it is important to predict the duration of consciousness recovery using MRI.

The current study demonstrated that lesions in the brainstem were especially associated with low GCS scores.

Patients with severe TBI may remain comatose for extended periods of time in the presence of Brainstem DAI. Prognostic information in these situations is valuable to clinicians and family members, in terms of the possibility of recovery of consciousness and the potential for good functional recovery

## LIMITATIONS OF THE STUDY

Our study is a single centric prospective study for a period of one year. For further research and followup multicentric study with larger population and longer duration with randomisation can be more beneficial.

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