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Original research article

Analysis of diffuse axonal damage in patients with severe head trauma using clinical, radiologic, and postmortem data

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Abstract

Introduction: It is yet unclear what kind of long-term effects such widespread brain damage would have. Apart from the etiology of subdural hematomas and coup injuries, which are characteristic of outer focal head trauma, widespread degeneration of cerebral white matter is linked to sagittal and lateral acceleration with centroaxial trauma. Diffuse axonal injury has a higher mortality rate than outer cerebral injury, with over 50% of sufferers passing away within two weeks.

Methods: Between February 2022 to January 2023, at Department of Neurosurgery, Gandhi Medical College, Secunderabad, Hyderabad, Telangana, India, conducted a prospective cross-sectional research of 30 patients.

Results: Pathognomonic lesions were found at autopsy in this investigation, even though CT brain scans were normal in most patients. Hypoxic changes including cellular swelling, Microhemorrages, white matter degeneration, and axonal swelling were observed on microscopic examination. The most frequent of these was hypoxic changes accompanied by cell enlargement.

Conclusion: Our research shows that the results of a CT of the brain do not reliably predict how severe a patient's head injury would be. Studies performed after death have determined that hypoxia and free radicals were major contributors to death, specifically edema in the brain stem and corpus callosum. The researcher plans to tackle these issues in future studies by doing biochemical analytical studies and studies with larger samples.

Keywords: Clinical-radiologic-post mortem, diffuse axonal injury, severe head injury

Introduction

When it comes to brain damage, the old saying that "the dead teach the living" rings truer than ever. Even with the finest care, most people who sustain severe brain injuries don't make it, and those who do often wind themselves in the Forensic Department. In light of the difficulty and difficulty of the task presented to the treating Neurosurgeon by cases of diffuse closed head trauma sustained from high-speed automobile accidents, this study was undertaken to analyze the Glasgow Coma Scale, clinical signs, radiological findings, gross and microscopic postmortem findings [1-3].

It is yet unclear what kind of long-term effects such widespread brain damage would have. Apart from the etiology of subdural hematomas and coup injuries, which are characteristic of outer focal head trauma, widespread degeneration of cerebral white matter is linked to sagittal and lateral acceleration with centroaxial trauma [4, 5]. Diffuse axonal injury has a higher mortality rate than outer cerebral injury, with over 50% of sufferers passing away within two weeks. People in this condition typically do not experience any periods of consciousness before dying; instead, they remain permanently unconscious, vegetative, or severely crippled. Skull fractures, subdural hemorrhages, or other intracranial mass effect, and outer brain contusions are less common in people with diffuse axonal injury after head trauma [5-7].

The documented instances all show autopsy evidence of primary brainstem injury. Accidents involving rapid acceleration and deceleration, such as those that occur frequently in traffic, can cause diffuse axonal damage. Concussion is the result of less severe diffuse axonal damage [7-9].

Traumatic brain injuries are one of the primary causes of death and disability among young people in the United States and Western Europe. Each year, over 50,000 people in these countries die from their injuries, and another 80,000 become crippled as a result. The monetary and financial toll of fatalities and severely injured victims is heavy on any nation's budget. According to one WHO statistic, injuries account for 3.5 million deaths annually around the world; of those, 700,000 occur as a result of vehicular mishaps. According to the same source, 1.5 million people had to get medical attention. The total cost of treatment and recovery was estimated by Nakajima *et al*. to be $5,000,000,000,000. The monetary loss brought on by these incidents is enormous [8-10].

Growing numbers of accidents in India, another developing country, have led to the loss of young lives

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as well as emotional and financial strain on families. Each year, more than 60,000 people are killed in road accidents in India, and a similar number perish from other types of injuries. According to Ramamurthy, annual losses due to accidents cost Rs 350 crores. Right now, that number is far larger. Road traffic accidents account for 70 percent of all injuries in India, and 70 percent of all deaths from traffic accidents are caused by trauma to the brain. The majority of fatalities from these accidents take place during the first 72 hours [10, 11].

There has been a rise in the incidence of deadly incidents in India recently. While only one percent of the world's automobiles are on Indian roads, the country has the highest accident rate in the world at six percent, according to data from 1991. There are currently around 600,000 car accidents in India every year. There is a fatality every eighth minute and an accident every minute. The New York Times claimed in 1987 that India had the highest fatality rate in the world, with 55 deaths per every 10,000 automobiles on the road. Diffuse axonal injury in severe head-injury patients was the impetus for developing this method of dissecting the clinical, radiological, and gross and histological postmortem characteristics of this condition. The purpose of this study was to characterize Diffuse Axonal Damage in individuals with severe head trauma by examining their clinical, radiological, and gross and histological postmortem characteristics [10-12].

Materials and Methods

Between February 2022 to January 2023, at Department of Neurosurgery, Gandhi Medical College, Secunderabad, Hyderabad, Telangana, India, conducted a prospective cross-sectional research of 30 patients.

Inclusion criteria

1. Patients with severe head injuries (GCS 8) who were hospitalized to the neurosurgical ward at the Institute of Neurosurgery, Gandhi Medical College were included in the study.

Exclusion criteria

2. Injured patients with significant parenchymal tissue
3. Extraaxial and intraaxial hematoma patients
4. Those with many wounds
5. Participants who declined to participate in the study

Patients were enrolled in the trial if they had been hospitalized to the neurosurgical unit following a Serious Head Injury and their CT brain scan showed evidence of diffuse axonal damage. Radiologic characteristics were evaluated, and demographic information was gathered. Patients who passed away while receiving therapy were included in the study, and autopsies were performed to examine characteristics of diffuse brain injury. Throughout the study period, our hospital admitted around 50 patients per day to the Trauma Ward due to injuries sustained in motor vehicle accidents, falls, assaults, and workplace mishaps, among other causes.

Results

The following table presents an overview of the findings from this investigation.

Age

In this particular research endeavor, the youngest patient was 18 years old while the oldest patient was 85 years old. 43 years of age was the mean.

Table 1: Age of the Patients

Age	Number
<20	2
20-29	3
30-39	8
40-49	3
50-59	7
60& above	7
	30

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Table 2: Sex of the Patients

Patients	Frequency	Percent
Male	22	73.33
Female	6	26.66
Total	30	100.0

Seizures

In our study 17 out of 30 patients had seizure, of them 10 patients had seizure on the day of injury.

Table 3: Medical Condition of the patient

Medical Condition	Frequency	Percent
Seizure	15	50.00
Without seizure	15	50.00
Total	30	100.0

Vomiting

In this study 14 patients had vomiting.

Table 4: Vomiting

	Frequency	Percent
Present	14	46.66
Absent	16	53.33
Total	30	100.0

ENT Bleed

In this study 10 patients had ENT bleed.

Table 5: ENT Bleed

	Frequency	Percent
Present	10	33.33
Absent	20	66.66
Total	30	100.0

Discussion

In this analysis, pathognomonic lesions were discovered at autopsy, despite the fact that CT brain scans appeared normal in the majority of patients. The microscopic inspection revealed hypoxic abnormalities such as cellular enlargement, microhemorrhages, white matter degeneration and axonal swelling. These changes were caused by oxygen deprivation. The hypoxic changes that were accompanied by cell expansion were the ones that occurred most frequently. In the study by Parker *et al*., the autopsy microscopic results predominantly featured diffuse degeneration of cerebral white matter, whereas in our investigation, the findings primarily showed Hypoxic Alteration with cellular swelling [11-13].

In 1955, Lindenberg and colleagues discovered 51 patients who had suffered white matter shear injury and posttraumatic hemorrhage of the corpus callosum. Posttraumatic white matter shearing injury can manifest as diffuse degeneration of white matter, which was first recognized by Strich. This injury can occur after a traumatic event. It was discovered that the corpus callosum, the internal capsule, the brain stem, the fornices, the anterior commissures, and the subcortical region are all susceptible to this kind of damage. Because there was no commonly accepted definition of DAI for a considerable amount of time, the basal ganglia and the internal capsule were thought to fall under the same category as the corticomedullary junction, the corpus callosum, and the upper brain stem. In order to properly define the autopsy, clinical, and neuropathologic results of DAI, major contributions were made by Adams and his colleagues. The imaging results were based on an arbitrary application of the pathologic classification suggested by Adams *et al*. Because no other approach has been proposed in the literature, we were forced to adopt the classification system that was published by Gentry in order to classify DAI that was discovered by MRI. Diffuse axonal damage (DAI) may only impact the white matter of the frontal and parietal lobes, the posterior section of the corpus callosum, and the top of the brain stem if this plan is carried out [14-16].

Individuals diagnosed with DAI almost often display severe post-traumatic cognitive impairment. The long-term GOS score has a negative correlation with the number of lesions that are discovered. It is therefore of significant clinical importance to be able to predict the result using the imaging method that is both the most sensitive and the least invasive. DAI is detected in the brains of between 80 and 100 percent of persons who pass away as a result of a head injury, as discovered by researchers. As a result, the lack of DAI lesions on the CT scan is a potential source of severe diagnostic error. Both MRI and CT scans have sensitivities that are about the same when it comes to detecting hemorrhagic lesions. Even

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though they were less obvious, the lesions were still apparent with CT scan in each and every case of hemorrhagic DAI that was examined in this investigation, with the exception of one. On the other hand, the majority of lesions do not bleed, and because of this, MRI is more effective than CT scan. We discovered 19 DAI lesions that were not hemorrhagic and 5 DAI lesions that were hemorrhagic, which lends credence to the aforementioned descriptions in the literature. Because of this, MRI is an essential part of the evaluation process for patients who have neurological impairment and a diagnostic probability of DAI despite having a negative CT scan. There is an insufficient amount of research that examines the connection between imaging and outcome. However, the presence of blood within DAI-type lesions is a poor prognostic factor, as demonstrated by the findings of the current study. Isolated DAI-type lesions without bleeding do not predict a poor clinical outcome. Previous study that found non-hemorrhagic characteristics in mild and severe DAI lesions has been confirmed by our findings. As Mendelsohn *et al*. found, the presence of callosal lesions on an MRI is not always an indicator of a poor prognosis. According to Adams *et al*., the phases of DAI progress more deeply into the body in a decreasing order as the severity of the trauma increases. The recent investigation provided additional evidence for this assertion [15-17].

The present investigation is flawed as a result of the bias that was introduced throughout the process of patient selection. Patients with DAI2 and DAI were more likely to have an MRI performed than patients with DAI1 because there was a disparity between the findings of CT scans and the patients' neurologic states. The small sample size also prohibits us from isolating the impact of concomitant lesions on outcome, such as SAH and contusions, which is a significant drawback of the study. Patients who also suffered with SCGMI fared poorly, for example, as a whole. These findings provide evidence that supports the conclusions drawn from earlier research that patients with DAI and SCGMI had a worse prognosis than individuals with DAI lesions alone. Moreover, intraventricular hemorrhage was associated with a gloomy prognosis. To summarize, no one had a successful outcome after undergoing surgery at the same time as a lesion [18]. However, there are no articles that address the optimization of MRI pulse sequences for the diagnosis of DAI, and more recent MRI approaches imply that the fraction of hemorrhagic DAI lesions is larger than was previously suspected1. This problem is crucial in a practical sense since it is difficult to monitor patients who have DAI while they are in the examination room, and examination time should be shortened as much as is practically possible. The sequences that were settled on for this study bring the whole examination duration down to a more reasonable 11 minutes while also incorporating unique, speedy, and blood-sensitive techniques. When comparing MRI and CT scanning for the diagnosis of traumatic brain lesions, it is evident that MRI is more sensitive, particularly for the detection of nonhemorrhagic DAI type-lesions. This is because MRI uses magnetic resonance imaging rather than computed tomography. Imaging through multiplanar MRI and T2-weighted sequences that have been specifically designed are required for this aim. It would appear that the presence of hemorrhage in DAI-type lesions and the relationship with traumatic space occupying lesions are additional negative prognostic markers. This would be in addition to the well-known significance of the GCS in determining the prognosis of the outcome for patients who have sustained a closed head injury. The findings of the current study indicate that isolated edematous nonhemorrhagic DAI lesions that are not detectable on CT scan are not connected with poor clinical outcome, which is in contrast to the findings of prior studies that have been published in the relevant body of academic research [18-20].

Conclusion

More than half of the patients with a clinical severity rating 3 perished. Skull fractures were less common in patients with severe DAI compared to those with milder DAI. CT scans of the brain were normal in one-third of individuals. SAH was the most common major finding at autopsy. Cellular expansion was observed as a result of hypoxia, which was statistically significant across all metrics. Microscopic testing demonstrated statistically significant lesion prevalence even in subjects with normal brain CT images. The statistical significance of microscopic lesions in the thalamus was higher. According to our findings, a CT brain scan's accuracy in estimating the severity of a patient's head injury is questionable. Postmortem examinations have revealed that edema in the brain stem and corpus callosum was caused by hypoxia and free radicals. The researcher intends to conduct biochemical analytical investigations and larger-scale studies to address these concerns in subsequent study.

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