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ROLE OF MRI IN THE EVALUATION OF DIFFUSE AXONAL INJURY

Radiodiagnosis

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ABSTRACT

INTRODUCTION: Diffuse axonal injury (DAI) is a relatively less common but severe form of traumatic brain injury. It occurs due to shearing forces and is identified as one of the most important causes of morbidity and mortality in patients with traumatic brain injury. MRI is found to be diagnostic when CT findings are normal and there are persistent unexplained neurologic findings or at subacute and chronic periods.
AIM: To evaluate the role of MRI in the diagnosis of diffuse axonal injury.
MATERIALAND METHODS: 9 Subjects were identified retrospectively with the diagnosis of DAI on MRI in last 2 years. The 1.5T MRI scans of the patients with DAI included: T1 and T2- weighted imaging, FLAIR imaging and T2*-weighted gradient echo (GRE) imaging. Lesions were identified and compared on all sequences.
RESULTS: The lesions were in cerebral white matter location in the cases of mild DAI, whereas in the severe DAI located in basal ganglia, corpus callosum, dorsal part of the brain stem as well as the cerebral white matter. For Haemorrhagic lesions, GRE is the best tool to detect haemorrhagic DAIs. For Non-haemorrhagic lesion, FLAIR and DWI are the best current tool to detect small and non-haemorrhagic parenchymal lesions, displayed as hyperintense lesions.

KEYWORDS

Diffuse axonal injury; MRI imaging; head injury; white matter; Shearing injury.

INTRODUCTION

Diffuse axonal injury (DAI) is a severe form of traumatic brain injury. It occurs due to shearing forces and is identified as one of the most important causes of morbidity and mortality in patients with traumatic brain injury.

Diffuse axonal injury is one of the major causes of unconsciousness, profound neurologic deficits and persistent vegetative state after head trauma. In recent years, MR imaging has been gaining popularity as an adjunctive imaging method in patients with DAI.

Diffuse Axonal Injury (DAI), initially described by Strich in 1956, is a rarely occurring consequence of traumatic brain injury (TBI)(1). For many years, diagnosis and identification of DAI was very limited. Brain computed tomography (CT) is the first line radiological imaging to describe consequences of injury, but does not correspond well to the Glasgow coma scale (GCS) score and neurological state. The brain MRI has become especially important in the imaging and confirming diagnosis of DAI.(2-6)

AIMS AND OBJECTIVES:

To evaluate role of MRI in the diagnosis of diffuse axonal injury.

MATERIALS AND METHODS:

9 Subjects were identified retrospectively with the diagnosis of DAI on MRI in last 2 years fulfilling the following criteria:
1) Unconsciousness from the time of injury that persisted beyond 6 h;
2) No cause of found for unconsciousness other than the primary brain injury;
3) The evidence of white matter injury on MRI.

The 1.5T MRI scans of the patients with DAI included: T1 and T2-weighted imaging, FLAIR imaging T2-weighted gradient echo (GRE) imaging. Lesions were identified and compared on all sequences.

RESULTS:

FINDINGS ON MRI IN DIFFUSION WEIGHTED IMAGING:

The lesions were in cerebral white matter location in the cases of mild DAI, whereas in the severe DAI located in basal ganglia, corpus callosum and dorsal part of the brain stem as well as the cerebral white matter. For Haemorrhagic lesions, GRE is the best tool to detect hemorrhagic DAIs. For Non-hemorrhagic lesion, FLAIR and DWI are the best current tool to detect small and non-hemorrhagic parenchymal lesions, displayed as hyperintense lesions

We detected 124 lesions in 9 patients on MRI. Table no. 1 depicts the number of lesions in each separate area of the brain. Approximate half of the lesions were located in the gray matter–white matter junction, which is one of the most characteristic sites involved in DAI. Some lesions were found in the thalami, basal ganglia(Figure 1a), corpus callosum(Figure 1b) and brainstem, which are also common components of the lesions of DAI.

Table no.2 depicts the number of lesions identified by each sequence. T2*-weighted GRE images were significantly more sensitive than FLAIR and DWI in the detection of DAI. On DWI, many lesions were hyperintense(Figure 2a) and on corresponding ADC images the lesions were hypointense(figure 2b), consistent with true diffusion restriction. DWI sequence detected only 31% of the lesions, but it could depict additional shearing injuries not visible on either T2*-weighted GE imaging or FLAIR. 87 lesions (70%) were detected by T2*-weighted GRE imaging corresponding with haemorrhages(figure 1a,1b&3a) and 51 (41%) were hyperintense on FLAIR imaging(Figure 3b).

Table no.1 Anatomical locations involved:

Anatomical location	No. of cases(%)
Subcortical and deep white matter	**62 (50%)**
Corpus callosum	**9 (7.2%)**
Basal ganglia/thalami	**18 (14.5)**
Brainstem	**6 (4.8%)**
Others	**29 (23.4%)**
Total	**124 (100%)**

Table no.2 No. of lesions identified by each sequence:

Name of sequence on MRI	No. of lesions detected by the sequence
DWI+, T2/FLAIR+, GRE+	**23**
DWI+, T2/FLAIR+, GRE−	**3**
DWI+, T2/FLAIR−, GRE−	**12**
DWI+, T2/FLAIR-, GRE+	**2**
DWI−, T2/FLAIR+, GRE+	**17**
DWI−, T2/FLAIR+, GRE−	**8**
DWI−, T2/FLAIR−, GRE+	**46**

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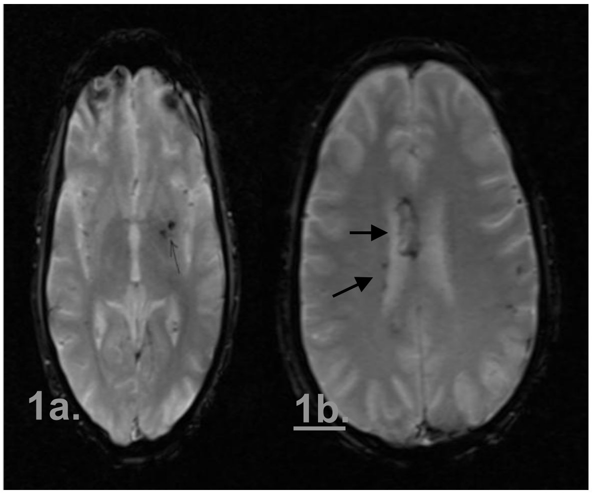

Figure 1. Axial brain image of 19 year old male, a case of road traffic accident showing hypointense areas(blooming) in right left ganglio-capsular region(figure 1a.) , body of corpus callosum and right thalamo-capsular region (figure 1b.)on GRE sequence.

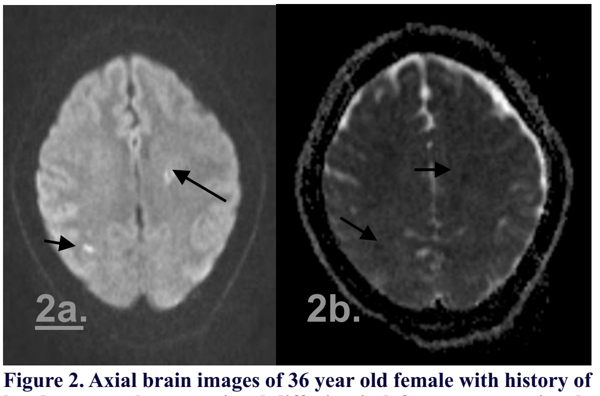

Figure 2. Axial brain images of 36 year old female with history of head trauma show restricted diffusion in left centrum semiovale and right parietal region.

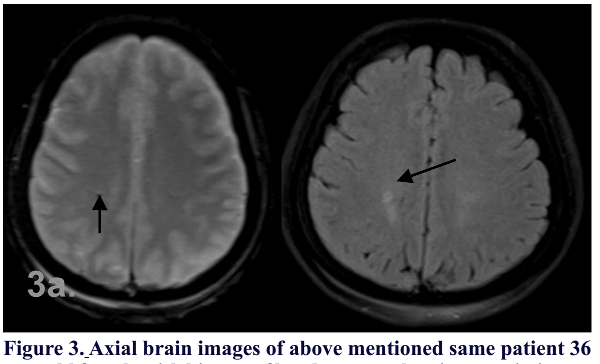

Figure 3. Axial brain images of above mentioned same patient 36 year old female with history of head trauma showing restriction on GRE(figure 3a) with perifocal hyperintense edema on T2 FLAIR sequence (figure 3b)in right centrum semiovale.

DISCUSSION:

Traumatic brain injury (TBI) is classified in two main categories as focal brain injury and diffuses brain injuries. Focal brain injuries, as cerebral contusions and cerebral hematomas result from direct impact on head (7). Diffuse brain injuries are result of diffuse shearing and tensile strains of the brain caused by different rotation or deceleration of adjacent tissues that differ in density, rigidity and gravitational factors(8,9).MRI is found to be diagnostic when CT findings are normal and there are persistent unexplained neurologic findings or at subacute and chronic periods.

An early and complete radiological workup of traumatic brain injury patients is mandatory to decide treatment and to give an indication of prognosis. CT and conventional MRI are both sensitive in diagnosing traumatic injuries. However, the identification of DAI is difficult on CT than MRI. CT significantly underestimates the extent of injury (10). Lesions can be macro or microscopic, T2*-GRE sequences are sensitive in detecting micro-haemorrhages also. The wide majority of shearing injuries are seen to be non-haemorrhagic (11).

In our study, the location and distribution of the encountered lesions were in accordance with the known predilection sites of shearing axonal injuries. MRI is useful for detecting DAI. It enabled the identification of non-haemorrhagic as well as haemorrhagic lesions in 9 patients with diffuse axonal injury. DAI studies using T2-weighted GRE imaging had demonstrated significant abnormalities, which appear normal on conventional MRI. MRI T2-weighted imaging is particularly helpful in confirming the diagnosis of DAI. In addition, the depicted MRI T2-weighted findings were useful in identifying haemorrhagic lesions which occur in 10–30% of patients with DAI because of the higher sensitivity to the susceptibility effects of blood products.

CONCLUSION:

Although DAI is least common consequence to brain trauma, DAI has a significant impact on the traumatic patients in terms of neurological condition as well as the need for rehabilitation.

CT has primary role in TBI, mainly for excluding acute hematomas or fractures in view of surgical intervention.

On the other hand, MRI is very crucial and superior in depicting DAI, in cases where the initial CT is negative but there are persistent unexplained neurologic findings. MRI correlates better with the diagnosis and severity of DAI. Our study concludes that MRI, with additional DWI and T2 FLAIR & GRE imaging is an indispensible supplemental tool for assessing the true extent of DAI in the patients with traumatic brain injury.

ABBREVIATIONS: MRI (magnetic resonance imaging), DAI (Diffuse axonal injury), FLAIR (fluid-attenuated inversion recovery), GRE (gradient echo).

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