Role of Apparent Diffusion Coefficient and its Comparison with Conventional MRI in Evaluation of Acute Encephalitis

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ABSTRACT

Introduction: Encephalitis is defined as inflammation of the brain parenchyma. Study was done to determine the role of DWI/ADC in the early diagnosis of acute viral encephalitis.

Material and methods: 26 patients with clinical and laboratory (CSF, blood culture) evidence of encephalitis were prospectively evaluated with MRI, DWI/ADC and SWI with patients divided into three groups on the basis of duration between the onset of clinical symptoms and timing of MRI brain.

Results: Of the total 26 patients imaged with age range of 3-70 years (mean age 45 years), 20 were males and 6 were females with a male to female ratio of 3.3:1. Group 1 comprised 8 patients, group 2 and group 3 comprised 9 patients each. P-values were significant ($p<0.05$) between mean ADC values and their respective groups. We also found statistically significant difference between group 2 and group 3 ($p=0.041$) with no statistically significant difference between groups 1 and 2; and groups 1 and 3.

Conclusion: MRI plays vital role in patients of acute encephalitis in not only excluding intracranial space occupying lesions but also in early diagnosis and specific treatment, thus reducing disease related morbidity and mortality. DWI/ADC is now an essential sequence in the colossal armamentarium of MRI sequences which not only helps in early diagnosis of acute viral encephalitis but also has prognostic implications.

Keywords: Apparent Diffusion Coefficient, MRI, Acute Encephalitis.

INTRODUCTION

Encephalitis defined as inflammation of the brain parenchyma is caused by a myriad of agents with viruses being the causative agent in majority of the cases. Aetiology varies as per the age and immune status of the patient,[1-3] the most common cause of sporadic acute encephalitis being herpes simplex virus (HSV) throughout the world.[4] The key to reducing high morbidity and mortality associated with acute HSV encephalitis lies in early diagnosis and subsequent effective antiviral drug administration.[5] Magnetic resonance imaging (MRI) is nowadays fundamental imaging modality in any febrile patient with altered sensorium. Conventional MRI sequences like T1WI, T2WI and FLAIR (Fluid Attenuated Inversion Recovery) may not be sensitive enough to detect early changes in brain parenchyma in viral encephalitis.[6,7] Diffusion-weighted imaging (DWI) now a sine qua non in early diagnosis of ischaemic stroke is being increasingly used in early diagnosis of acute encephalitis.[8-10] Few studies with limited sample size have validated the high sensitivity of DWI in acute encephalitis.[11,12] We undertook this study to analyse and highlight the effectiveness of DWI sequences in detecting the early changes in acute encephalitis.

MATERIAL AND METHODS

This was a prospective observational study conducted between October 2015 to December 2018 with approval from Institutional Ethical Committee (IEC). 26 patients, comprising 20 males and 6 females ranging from 3 to 70 years of age (mean age, 45 years), with clinical and laboratory (CSF, blood culture) evidence of encephalitis were prospectively evaluated with MRI, DWI/ADC and SWI. Informed consent was taken from all patients or their attendants. Patients with known contraindications to MRI (metallic implants, pacemaker etc.) were excluded from the study. All patients were examined by 3.0 T superconducting magnetic resonance imager (Magnetom Avanto, Siemens Medical System) with a standard head coil. After the preliminary localizer, the imaging protocol comprised of axial *T*1 weighted (*T*1W) spin echo sequence [repetition time/echo time (TR/TE) 500 ms/11 ms; slice thickness 5 mm; field of view (FOV) 230 mm], axial *T*2 weighted (*T*2W) turbo spin echo sequence (TR/TE 3500 ms/110 ms; slice thickness 5 mm; FOV 230 mm), axial fluid attenuated inversion recovery sequence (TR/TE/inversion time 8000 ms/108 ms/2500 ms; slice thickness 5 mm; FOV 230 mm), sagittal *T*1W spin echo sequence (TR/TE 450 ms/10 ms; slice thickness 5 mm; FOV 230 mm) and DWIs obtained by using an axial echoplanar SE sequence (TR/TE 3000 ms/87 ms), 2 averages, 5 mm section thickness, 230 × 230 FOV. DW images and ADC maps were acquired by using b-values of 0, 500, 1000 s mm^{-2}. ADC values were calculated on a picture archiving and communication system workstation by placing the region of interest (ROI) onto the 2-3 mm^2

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area of signal alteration regardless of white and grey matter and the values obtained were expressed in 10^{-3} mm^2 s^{-1}. 3-50 ROI areas were used for each patient in proportion to parenchymal involvement and arithmetic mean was taken. SWI images were obtained in axial plane with parameters as TR = 49 ms; TE = 40 ms; section thickness = 2.5 mm and FOV = 230 mm. SWI images were helpful in identifying the areas of haemorrhage and this area was carefully excluded from the area of interest. Depending on the time duration between onset of symptoms and brain MRI, patients were classified into three groups. Group 1 had a duration of 0-2 days (acute stage), group 2 (late acute to early subacute) had a duration of 3-7 days and group 3 (late subacute to chronic stage) with a duration of 8 or more days.[13]

STATISTICAL ANALYSES

The data was analysed using statistical softwares SPSS v 20 and STATA v 11. Continuous variables were described in terms of descriptive statistics like mean, standard deviation (SD), minimum, maximum and range. Relationship among mean ADC values and the groups was analysed using Kruskal Wallis test. All the results with p-values of less than 0.05 were considered significant.

RESULTS

Of the total 26 patients imaged with age range of 3-70 years (mean age 45 years), 20 were males and 6 were females with a male to female ratio of 3.3:1. Group 1 comprised 8 patients, group 2 and group 3 comprised 9 patients each. P- values were significant ($p<0.05$) between mean ADC values and their respective groups (table 1). We also found statistically significant difference between group 2 and group 3 ($p=0.041$) with no statistically significant difference between groups 1

Group	Mean ADC value ($x10^{-3}$ mm^2/s) ± SD	p-value
Group-1	0.967 ± 0.325	0.023
Group-2	1.039 ± 0.338	
Group-3	1.443 ± 0.231	

Table-1: ADC values of different groups and their correlation

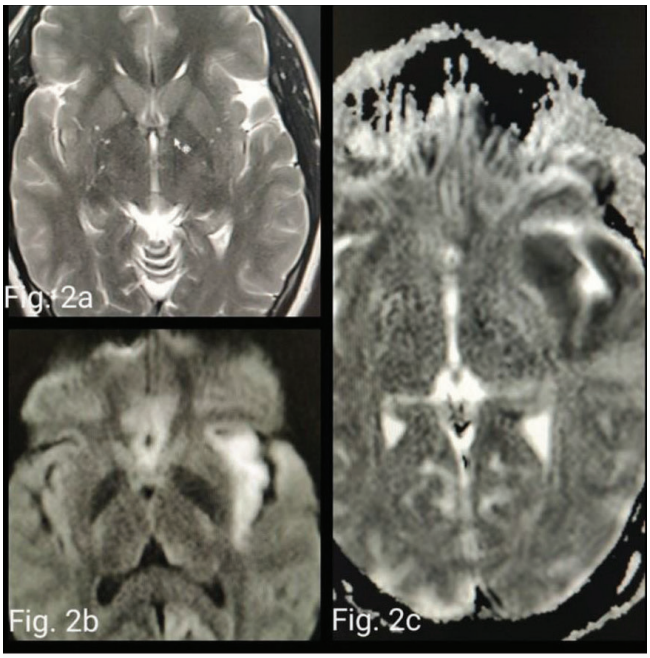

Figure 2: Axial T2W (a) image shows normal signal intensity in bilateral insular regions. DWI (b) and corresponding ADC (c) images show diffusion restriction in the left insula.

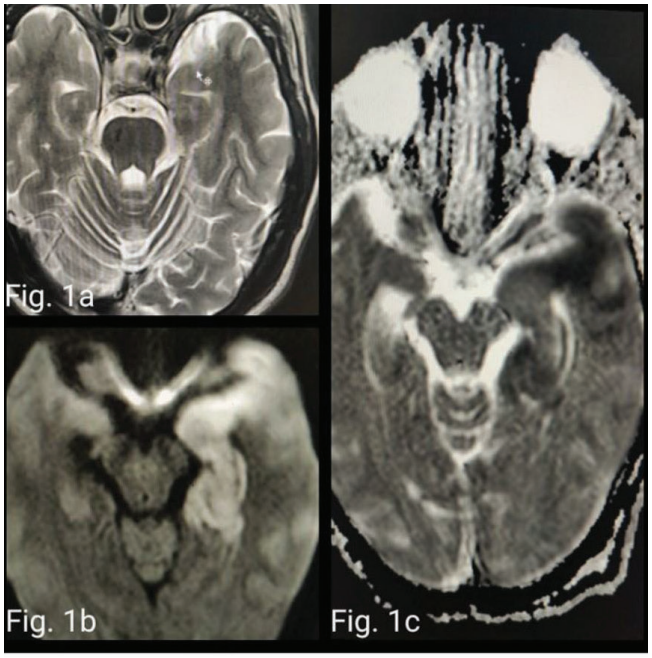

Figure 1: Axial T2W (a) image shows normal signal intensity in bilateral temporal lobes. DWI (b) and corresponding ADC (c) images show diffusion restriction in the left temporal lobe

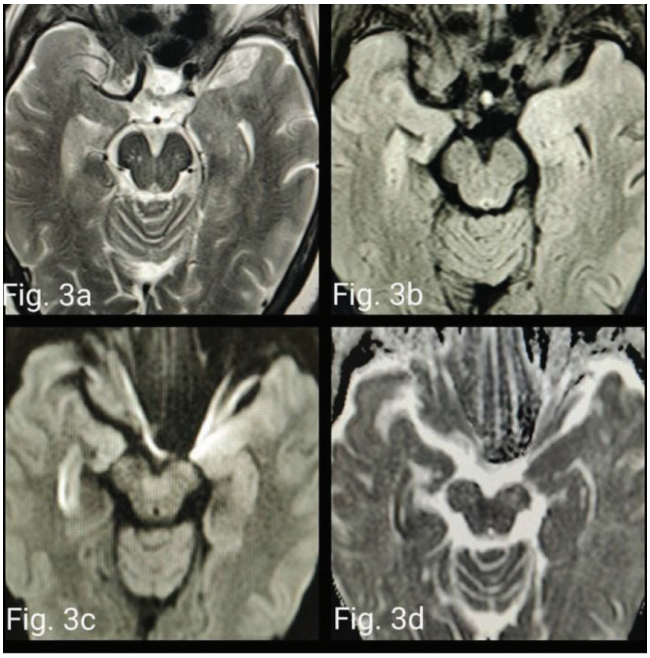

Figure 3: Axial T2W (a) and FLAIR (b) images show subtle asymmetrical hyperintensity in bilateral medial temporal lobes. DWI (c) and corresponding ADC (d) map show subtle diffusion restriction in bilateral temporal lobes.

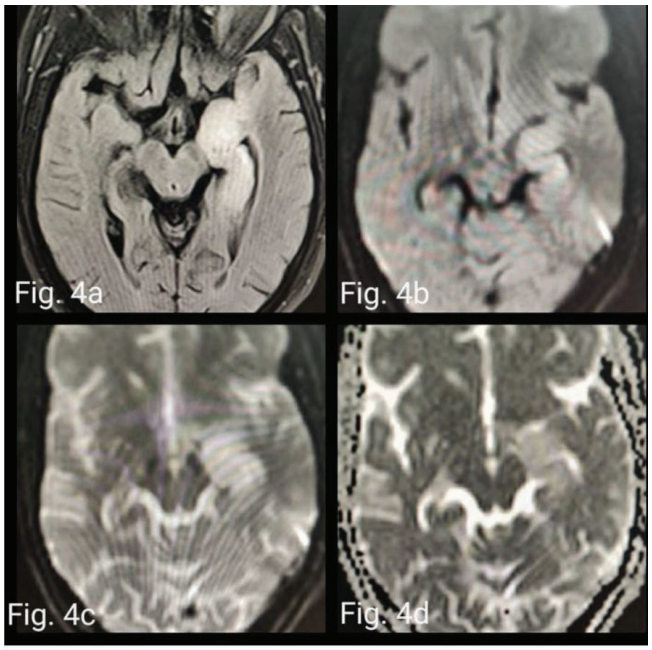

Figure 4: Axial FLAIR (a) image shows high signal intensity in the left medial temporal lobe. DWI-b500 (b), b1000 (c) and corresponding ADC (d) map shows free diffusion in the left medial temporal lobe.

and 2 and groups 1 and 3.

DISCUSSION

Varied presentation of brain parenchymal infections usually manifests either as symptoms related to infection and inflammation of meninges (meningitis), involvement of brain parenchyma (encephalitis) or both (meningoencephalitis).

Morbidity and mortality of acute encephalitis is related to the age and immune status of the patient.[14] Conventional imaging methods have limited role in only confirmation of the established diagnosis of encephalitis and follow up of post-encephalitic sequelae. Imaging demonstrates lesion location and extension, associated oedema and sometimes providing clues about the underlying aetiology; but clinical scenario and lab parameters are essential in most cases for identification of infectious agent.[15] DWI with ADC is now the most sensitive sequence to detect early viral invasion of brain parenchyma in viral encephalitis. Pathologically, early stages are characterised by congestion, inflammatory cell infiltrate around the vessels and intravascular thrombus formation.[16] The importance of diffusion sequences lies in its ability to detect the cytotoxic oedema of neuronal cell bodies in acute stages, which is manifested in the form of increased signal on DWI (diffusion restriction) with corresponding ADC map showing decreased signal intensity (fig. 1 and 2).[17,18] Diffusion restriction in late acute and early subacute stages diminishes with ADC values beginning to increase in the corresponding ADC map. In these stages, vasogenic oedema supersedes cytotoxic oedema with decrease in perivascular inflammatory response pathologically.[12] At this stage, vasogenic oedema also becomes visible as increased signal intensity on T2WI (fig. 3). Late subacute and chronic stages are characterised by increase amounts of necrosis and demyelination of white matter tracts. These changes are manifested as increased signal on T2W/FLAIR sequences with higher values on corresponding ADC map (fig. 4).[11] Kiroglu et al. and Prakash et al. in their studies of MR imaging of acute encephalitis found DWI superior to conventional MRI sequences in early stages of acute encephalitis and conventional sequences to be superior in late stages.[11,12] We also found DWI to be more sensitive in detecting cytotoxic oedema of early stages and conventional MRI (FLAIR) sequences to be more sensitive in detecting vasogenic oedema of late stages. However, contrary to these studies Tsuchiya et al. found FLAIR imaging to be equal or superior to DWI in acute stages.[2] This may be explained by the fact that acute encephalitis in some patients presents with extensive vasogenic oedema in acute stages. Furthermore, study by Sener RN et al. investigated correlation between ADC values and clinical prognosis in early stages of acute encephalitis and concluded that clinical presentations of patients with low ADC values (predominant cytotoxic oedema) was dismal when compared with patients having high ADC values (predominant vasogenic oedema).[19] Our study also suggested prognostic implication of ADC values in early stages of Herpes encephalitis. In our study, ADC values correlative inversely with extent of parenchymal and deep grey matter involvement.

In nutshell, MRI plays vital role in patients of acute encephalitis in not only excluding intracranial space occupying lesions but also in early diagnosis and specific treatment, thus reducing disease related morbidity and mortality. DWI/ADC is now an essential sequence in the colossal armamentarium of MRI sequences which not only helps in early diagnosis of acute viral encephalitis but also has prognostic implications.

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