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ORIGINAL RESEARCH

Role of magnetic resonance imaging in paediatric brain infections

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ABSTRACT INTRODUCTION
Aims and objectives: To study the role of Magnetic Resonance Imaging in diagnosis of paediatric brain infections, characterization of various patterns of brain involvement and establishing the differential diagnosis along with role of Diffusion Weighted Imaging and Apparent Diffusion Coefficient in Cerebral infections .
Materials and methods: 50 cases with suspected brain infection, whose age group ranged from 0-14 years, referred to the Department of Radiodiagnosis and Imaging, Government Medical College, Amritsar, were included in this study. The sequences performed were T1W axial, T2W axial, coronal and saggital, FLAIR axial, DWI/ADC, SWI,post contrast T1W in all patients and magnetic resonance spectroscopy wherever required. MRI findings in all cases along with magnetic resonance spectroscopy, clinical and biochemical findings (wherever required) were taken into consideration to arrive at a diagnosis.
Results:Outof50patients,mostcommonpathologywastubercularinfectionsseen in 25 patients (50%), followed by 18 patients of pyogenic meningitis (36%), 5 patients of NCC (10%) and 2 patients of viral encephalitis (4%). The most common finding in tubercular infections was meningeal enhancement followed by tuberculomas, basal exudatesand themostcommon complication was hydrocephalus. Themostcommon finding in pyogenic meningitis was meningeal enhancement and the most common complication was abscess. Neurocysticercosis lesions were parenchymal. Colloidal vesicular/granular nodular stage was seen in 3 patients, vesicular in 2 patients and calcified in 1 patient. Viral encephalitis was seen as areas of cerebral involvement bilaterally with restriction on DWI/ADC seen in onepatient.
Conclusions: MRI due to its variable intensities in multiple sequences aided by contrast enhancement helps the radiologist to arrive at an almost exact diagnosis. Italso drawssupportfromassociatedclinicalfeatures, lesion-staging, complicationsand number (single or multiple) of the lesions. Thus it scores over CT and ultrasound as basic modalities for imaging infective disease of brain inchildren.
Keywords:Magnetic resonance imaging, paediatric, neurocysticercosis, tubercular infection, pyogenic meningitis, viral encephalitis

INTRODUCTION

Infection of central nervous system pose a serious problem in paediatric population because they cause debilitating neurological sequelae if not recognized and adequately treated.[1]The severity depends on factors like stage of CNSdevelopment at the time of infection, virulence of the pathogen and the host immune response.[2]

The investigations used to establish the diagnosis include laboratory investigationsandimagingi.e.USG,CTscanandMRI.MRIatpresentisthetechnique of choice for investigating pediatric braininfections.[3]

MRI provides an accurate determination of brain involvement, lesion stage (acute, subacute or chronic) and, in some cases, a likely etiological hypothesis and effective technique for monitoring treatment .[4,5] MRI also helps in differentiating the different etiologies of brain infections like viral encephalitis, tubercular infection, neurocysticercosis and meningitis with the availability of contrast agents and advanced techniques such as diffusion-weighted imaging (DWI) and magnetic resonance spectroscopy (MRS).

MATERIALS AND METHODS

STUDY SITE

Government Medical College, Amritsar.

STUDY POPULATION

50 cases with suspected brain infection, whose age group ranged from 0-14 years, referred to the Department of Radiodiagnosis and Imaging, Government Medical College, Amritsar, were included in this study.

STUDY DESIGN

Observationalstudy

SAMPLE SIZE

50

DURATION OF STUDY

2years

Ethical clearance has been obtained from the Research and Dissertation Committee/ Ethical Committee of the institution for this study.

IMAGING TECHNIQUE

MR Imaging was performed using Siemens machine Aera 1.5 T. Conventional MRI sequences were performed using Fast Spin Echo (FSE) mode and slice thickness of6 mm. These included T1 weighted axial images with TR (repetition time) - 550ms, TE (time to echo) 8.9ms; T2 weighted axial, coronal and sagittal images with TR (repetition time)- 5000ms, TE (time to echo) - 92ms; FLAIR sequence axial image with TR (repetition time)- 9000ms, TE (time to echo)-86ms, TI (Inversion time)- 2500ms.

Diffusion weighted imaging (DWI) and apparent diffusion coefficient (ADC) imaging were performed using echo planar imaging sequence with TR/TE=4800 ms/ 89ms and diffusion sensitivity of b=0 and b=1000. SWI sequence was applied with TR-49 ms and TE- 40ms and slice thickness 3mm. Contrast enhanced T1 weighted sequence with axial, coronal and sagittal images. 0.1 ml/kg of intravenous gadodiamide was used as contrast agent.

RESULTS

Table I: Spectrum of CNSinfections

Diagnosis	No of patients	Percentage %
Pyogenic meningitis	18	36%
Tubercular etiology	25	50%
Viral encephalitis	2	04%
Neurocysticercosis	5	10%
Total	50	100%

Out of 50 patients most common pathology was tubercular infections seen in 25 patients (50%), followed by 18 patients of pyogenic meningitis (36%), 5 patientsofNCC (10%) and 2 patients of viral encephalitis (4%).

Themaximumnumberofpatientswereintheagegroupof>1&<=5yearsi.e. 17 patients accounting for 34 % of total number of patients. The least common age groupwas<=1yearagei.e.10patientsaccountingfor20%oftotalnumberofpatients.

Males were more affected than females. Most common clinical feature was fever seen in 40 patients (80%) followed by seizure in 32 patients (64%).

Table II: Spectrum of findings in tubercular CNS infection (n=25)

Findings	No of patients/total tubercularpatients	Percentage out of total tubercular patients (%)
Meningeal enhancement	23	92.00
Basal exudates	09	36.00
Tuberculoma	14	56.00

Outof25patientswithtubercularinfections,meningealenhancementwasseen in 23 patients (92%).Basal exudates were seen in 9 patients (36%). Tuberculomas wereseenin14patients(56%)whoincluded12patientswithmeningealenhancement and 2 patients with isolatedtuberculomas.

Table III: Spectrum of complications in tubercular CNS infection (Total number of patients =25)

Complication	No of patients/total tubercular patients (25)	Percentage out of total tubercular patients (%)
Hydrocephalus	10	40.00
Infarct	04	16.00
Abscess	01	04.00

Complications in tubercular infections were seen in 11 patients. Hydrocephalus was seen in 10 patients (40%) followed by infarct in 4 patients (16%) and abscess in 1 patient (4%).

In pyogenic meningitis, MRI findings included meningeal enhancement in all the 18 patients and complications in 5 patients including abscess in 3 patients (16%), ventriculitis in 2 patients (11%) and hydrocephalus in 1 patient (5.5%).

Neurocysticercosis was seen in 5 patients. The stages of lesions seen in 5 patients of neurocysticercosis were colloidal vesicular/granular nodular in 3 patients, vesicular in 2 patients and calcified in 1 patient. Scolex was seen in 2 patients with vesicular stage lesions.

Viralencephalitis was seen in 2male patients,bothbelongingto>1&<=5years age group. Fever and seizures were the presenting complaints in both patients. Both the patients showed cerebral lesions.

Diffusion restriction on DWI/ADC was seen in 2 patients of viral encephalitis and2patients oftuberculoma.Amongthecomplications,diffusionrestrictionwasseen in abscesses in 4 patients, infarcts in 4 patients and ventriculitis in 2patients.

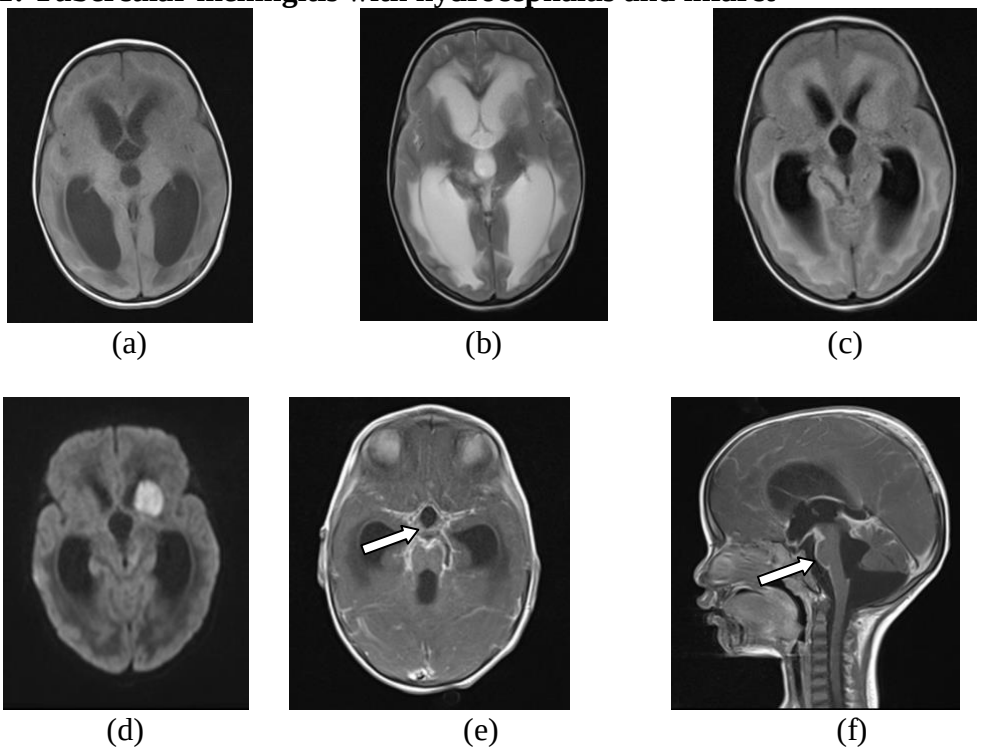
Ring enhancement on post contrast scans was seen in 3 patients with neurocysticercosis, 14 patients with tuberculoma. Nodular enhancement was seen in 2 patients with tuberculoma. Patchy enhancement was seen in 1 patient with viral encephalitis among the complications, ring enhancement was seen in abscesses in 4 patients and ependymal enhancement was seen in 2 cases with ventriculitis.

DISCUSSION

The incidence of tubercular infections was higher in >1 &<=5 years of age group. Most common imaging feature in tubercular meningitis was meningeal enhancement(96%)followed bytuberculomas(56%)andbasal exudates(36%).Most common complications seen in tubercular infections was hydrocephalus (40%) followed by infarct (16%) and abscess in 1 patient(4%).

Our findings match with the study by **Fatema K et al** [6] in which most common neuroimaging findings included tuberculoma (50%), hydrocephalus (54.8%), basal meningeal enhancement (33.8%) and infarcts in 25.8% cases. The findings in terms ofmeningealenhancementbeingthemostcommonfindingandhydrocephalusbeing the most common complication are in accordance with a study by **Uysal G etal**.[7]

Figure 1: Tubercular meningitis with hydrocephalus and infarct

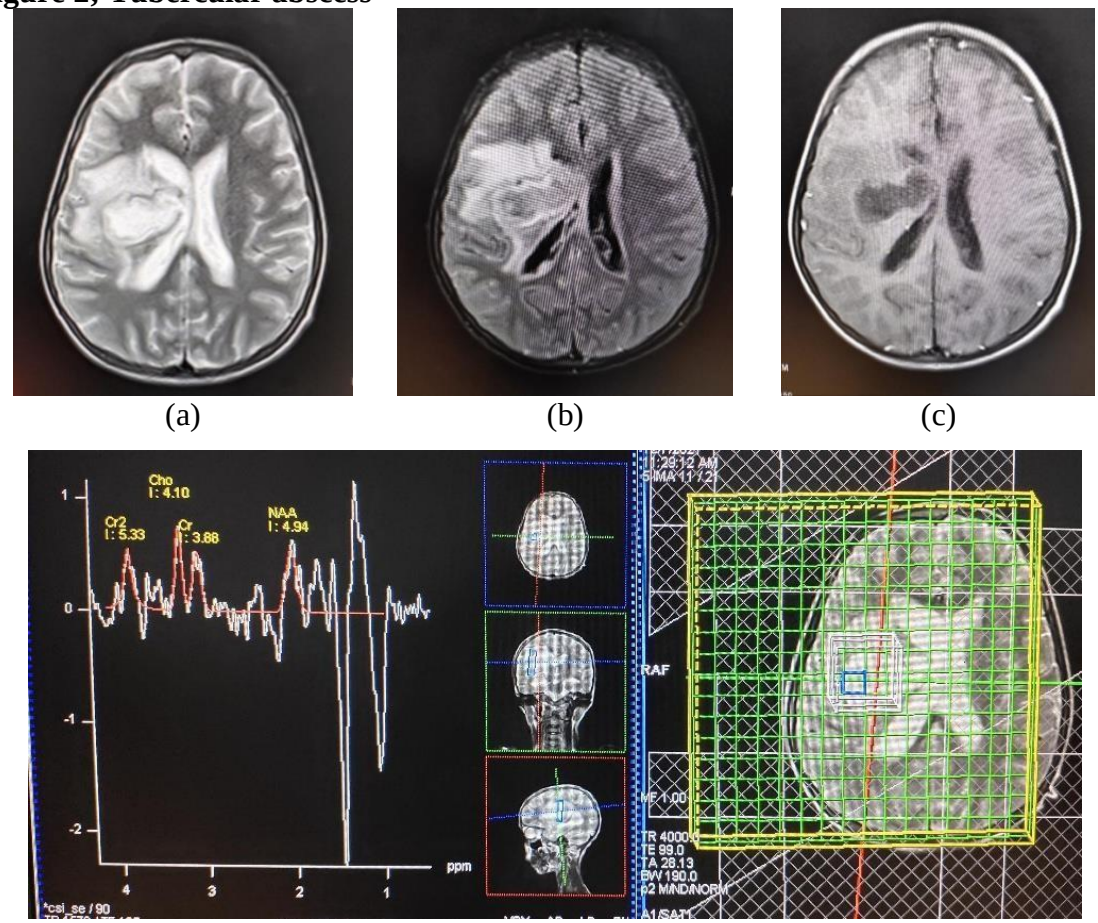


(a) (b) (c)

(d) (e) (f)

a) Axial T1W image , b) Axial T2W image , c) Axial FLAIR image: moderately dilated lateral and third ventricles are seen with periventricularooze
d) DWI image shows an area of restriction in left basal ganglia region – acute infarct
e) Axial post contrast T1W and f) sagittal post contrast T1W imagesshow enhancing basal exudates (whitearrows)

Figure 2; Tubercular abscess



(a) (b) (c)

(d)

a) a)Axial T2W image &
b) b) axial FLAIR image: A well defined , irregular , oval lesion showing hyperintense signal on T2/FLAIR sequences with perilesional edema is seen in right cerebral hemisphere
c) Post contrast T1W image: ring enhancement is seen on post contrast scan
d) MR spectroscopy image shows lipid lactatepeak

Patientswithtuberculoma(14patients)showedcerebrallesionsin10patients, cerebellar lesions in 5 patients and brainstem lesion in 1 patient. Most of the tuberculomas measured less than 10 mm in size in our study. In study by **Gupta RK et al**[8] most common location of tuberculomas was also cerebral hemispheres. Most common size of the tuberculomas was also less than 10mm in their study.

Most of the tuberculomasshowed isointense signal on T1W sequence as seen in 11out of 14 patients. Most of the tuberculomasshowedhypointensesignal on T2W and FLAIR sequences as seen in 09 out of 14 patients. Ring enhancement was seen in all 14 patients and nodular enhancement was seen in 2 patients with tuberculomas. Perilesional edema was seen in 13 patients with tuberculomas. Restriction on DWI/ADC was seen in tuberculomas in 2patients.

The incidence of pyogenic meningitis was higher in <=1 year age group.Fever was the most common symptom in pyogenic meningitis. In our study, MRI findings includedmeningealenhancementinall the18patientsandcomplications in 5 patients including abscess in 3 patients (16%), ventriculitis in 2 patients (11%) and hydrocephalus in 1 patient (5.5%). In the study by **Carlos R. Oliveira et al**,[9] the MRI findings included leptomeningeal enhancement as the most common finding which is similar to ourstudy.

In our study, >5 and <=14 years was the most common age group for neurocysticercosis with

females being more affected than males. The most common clinical feature was seizure seen in 5 patients followed by headache. Most commonpresentationwasparenchymallesionsinallcases.Allpatientswithneurocysticercosis showed hypointense lesions on T1W sequence, hyperintense lesions on T2W sequence. 3 patients with neurocysticercosis showed hyperintense signal lesions on FLAIRwhereas2patientsshowedhypointensesignallesionsi.e.signalsimilartoCSF on FLAIR sequence. Perilesional edema and ring enhancement was seen only in 3 patients. No diffusion restriction on DWI/ADC was seen in neurocysticercosislesions, which is in accordance with the study by **Raffin LS etal**.[10]

The stages of lesions seen in 5 patients of neurocysticercosis were colloidal vesicular/granular nodular in 3 patients, vesicular in 2 patients and calcified in 1 patient. Scolex was seen in 2 patients with vesicular stage lesions. No ventricular or subarachnoidlesionswereseen in ourstudy.In a studyby**MartinezHR etal,**[11]most common presentation of active lesions was also parenchymal and scolex was seen inside the vesicles.

Viral encephalitis lesions were cerebral lesions showing T1W hypointense, T2W & FLAIR hyperintense signal in 1 patient. In the other patient, the lesions showed isointense signal on T1W, T2W and FLAIR sequences. Patchy enhancement was seeninlesionsof1patient.NoperilesionaledemawasseenRestrictiononDWI/ADC wasseeninbothpatients.Asperastudyby**Kukeretal**[12]allthreepatientsofherpes simplex encephalitis which is a viral encephalitis showed DWI restriction in temporal and insularregions.

Abscess and infarcts were seen as hypointense lesions on T1W sequences and T2/FLAIR hyperintense lesions on T2W/FLAIR sequences.

RestrictiononDWI/ADCwas seen in abscessesinall4patients whichincluded 3 patients of pyogenic and 1 patient of tubercular infection. This is in accordance with study by **Luthra G et al.**[13] No restriction was seen in hydrocephalus. Infarcts in all 4 patients showed restriction.

Ventricular exudates in both the patients of ventriculitis showed diffusion restriction. In a study conducted by **Pezzullo JA et al**[14] in 3 patients with pyogenic ventriculitis, intraventricular debris showing marked diffusion restriction was seen in dependent occipital horn of lateral ventricle in all three patients.

Ependymal enhancement was seen in both patients of ventriculitis which is similartothestudyby**FukuiMBetal,**[15]inwhichependymalenhancementwasseen in 7 out of 11 cases in which contrast was administered. Infarcts and hydrocephalus showednoenhancement.Abscessesinall4 patientsshowedring enhancementwhich is in accordance with **Luthra G etal.**[13].

CONCLUSION

MRI due to its variable intensities in multiple sequences aided by contrast enhancement helps the radiologist to arrive at an almost exact diagnosis. It also draws support from associated clinical features, lesion-staging, complications and number (single or multiple) of the lesions. Thus it scores over CT and ultrasound as basic modalities for imaging infective disease of brain in children.

DWI/ADC showed restriction in cerebral hemispheres in viral encephalitis patient even when conventional sequences including T2/FLAIR were normal.

DWI/ADC was helpful in differentiating various ring enhancing lesions which included abscess, tuberculoma and neurocysticercosis. Restriction was seen in all abscesses, very uncommon in tuberculomas and no restriction was seen in neurocysticercosislesions.DWI/ADCwasalsohelpfulindiagnosingcomplicationslike ventriculitis andinfarcts.

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