Indian Journal of
Applied Radiology

Open Science Publications

Volume 6, Issue 1 - 2020

www.opensciencepublications.com

Diffusion Restriction: Its Diverse Implications in the Pediatric Brain

Case Series

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Article Information: **Submission: 27/09/2020; Accepted: 27/11/2020; Published: 30/11/2020**

Abstract

We present a case-series of 6 cases, which shows the different implications of the finding of diffusion restriction and how this finding, in combination with the clinical history and other relevant MR findings points out to a diagnosis in completely different spectra, which therefore has significant impact on the patient management.

Keywords: Diffusion restriction; Pediatric

Introduction

We present a case series of 6 cases, showing diverse etio-pathogenic spectrum in the underlying pathologic mechanism of the diffusion restriction seen on DWI images with corresponding hypointensity seen on ADC maps.

The spectrum includes infarctions (arterial as well as venous), auto regulatory disorders like PRES, global hypoxia and hypo perfusion (HIE), trauma (DAI), Infections (TB, pyogenic abscess), Toxic and metabolic disease (Mitochondrial disorders, hypoglycemia, urea cycle defects), Demyelination (ADEM, MS) and neoplasm (Gliomas, medulloblastomas, Choroid plexus tumors etc.).

Diffusion-Weighted Imaging (DWI) has also become a pillar of current neuroimaging. Diffusion abnormalities represent alterations in the random movement of water molecules in tissues, revealing their micro architecture, and occur in many neurological conditions. DWI provides useful information, increasing the sensitivity of MRI as a diagnostic tool, narrowing the differential diagnosis, providing prognostic information, aiding in treatment planning and evaluating response to treatment.

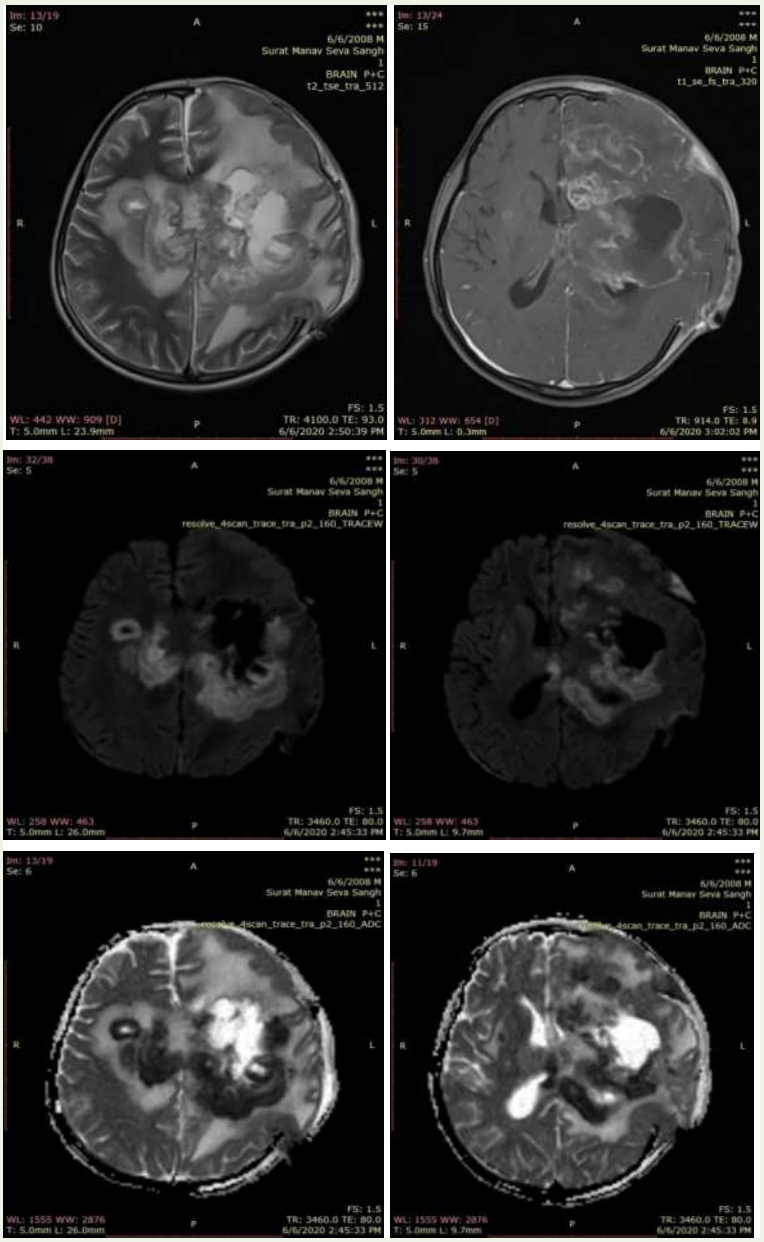
DWI provides image contrast that is dependent on the molecular motion of water.

Diffusion abnormalities represent alterations in the random movement of water molecules in tissues, revealing their micro architecture, and occur in many neurological conditions [1]. In a DWI sequence diffusion sensitization gradients are applied on either side of the 180° refocusing pulse. The parameter "b value" decides the diffusion weighting and is expressed in s/mm2. It is proportional to the square of the amplitude and duration of the gradient applied. Diffusion is qualitatively evaluated on trace images and quantitatively by the parameter called Apparent Diffusion Coefficient (ADC). Tissues with restricted diffusion are bright on the trace image and hypo intense on the ADC map. In the brain, factors contributing to the measured ADC include true random diffusion, tortuosity of the diffusion space, cytosolic streaming, exchange times between compartments and restriction by cell membranes

Case 1

This patient was an 8 years old child who presented with c/o fever and seizures and was advised MRI-Brain study; MRI revealed

ISSN: 2581-3919



Case 1: Infective spectrum.

multiple conglomerate T2-hypointense lesions which show diffusion restriction in left front parietal region, basal ganglia, body of corpus callosum, right centrum semiovale, with perilesional vasogenic edema seen. Most of these showed peripheral post contrast enhancement. These were diagnosed as Infective Tuberculomas and Tubercular abscesses, which was confirmed on histopathology. The patient responded well to ATT

Case 2

These images show multiple T2-FLAIR hyper intense lesions in bilateral centrum semiovale, corona radiata, corpus callosum as well as in the subcortical and periventricular white matter with diffusion restriction seen in splenium of corpus callosum in a 5 years old child with c/o fever, altered sensorium. Findings were s/o acute leukoencephalopathy

Case 3

These sets of DWI-ADC images of an infant with altered sensorium show a large lobulated solid-cystic lesion in the temporal, occipital horns and body of lateral ventricle on left side, with the solid component showing patchy diffusion restriction. It causes mass-effect with midline shift of 12 mm towards right side and is infiltrating into the left temporoparietal neuroparenchyma. The lesion was diagnosed as a malignant neoplastic etiology of choroid plexus origin, Choroid

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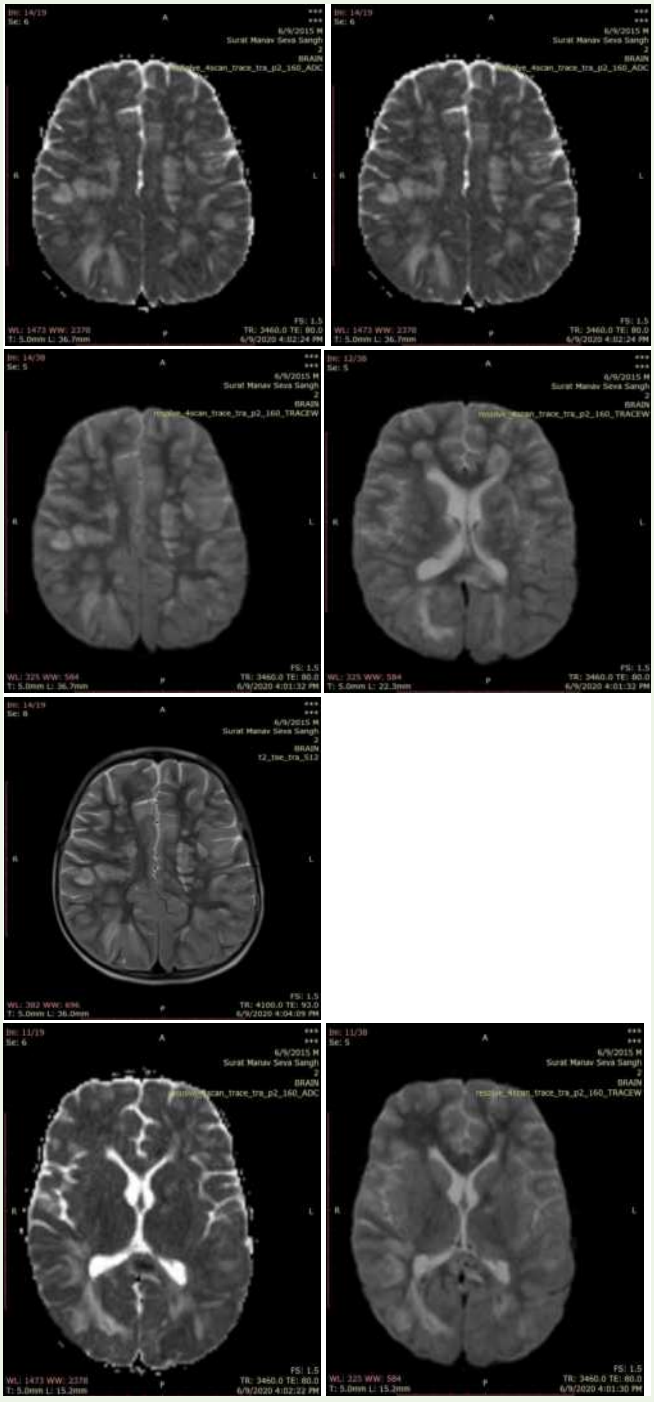

Case 2: Leuko-encephalopathy spectrum.

plexus carcinoma. The radiological diagnosis was corroborated with histopathological diagnosis obtained post-surgical excision.

Case 4

The patient was a 6 years old pediatric patient, who presented with fever, nuchal rigidity and vomiting; CSF analysis revealed leucocytosis with differential neutrophilia and low CSF sugar levels; These images show diffusion restriction in left cerebral hemisphere, left basal ganglia, bilateral thalami mainly involving the cortex (i.e. gray matter) with partly involving subcortical white matter; Such a pattern of restriction differentiates infarct from encephalitis; Infarct involves loss of GM-WM differentiation with diffusion restriction, as opposed to the cortical restricting pattern seen here.

The child responded well to intravenous antibiotics.

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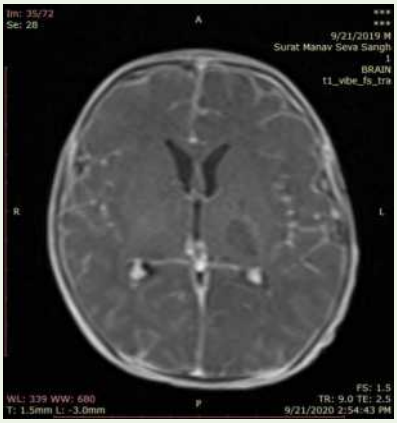


Additionally, T1 Post contrast images show exaggerated meningeal enhancement without abnormal enhancement of the cortex or basal ganglia, Represents changes of meningo-encephalitis.

Case 5

This patient was 4 year old child who presented with right sided hemiplegia; MRI study revealed an ill-defined area of diffusion restriction with corresponding low ADC value in left frontal region and insular cortex (Perisylvian distribution). No e/o any blooming foci seen on GRE.

Represents acute non-haemmorhagic infarct.

Additionally gyral thinning with sulcal space widening seen in left cerebral hemisphere, s/o left sided hemi-atrophy

Left sided MCA, PCA and right ACA were not visualized, s/o complete thrombosis.

Possible differentials were Hemiconvulsion Hemiplegia Epilepsy Syndrome (HHE) more likely Moya –moya like disease, less likely.

Follow-up work up for ruling out Moya-Moya revealed no supportive finding; The child later also went on to develop seizures also, which confirmed the diagnosis of HHE.

These images shows diffusion restriction in bilateral Globus pallidus, in an infant who presented with seizures and excessive drowsiness. Initially diagnosed with?encephalitis clinically, Biochemical investigations revealed Hyperammonemia with deranged LFTs. Final diagnosis of metabolic encephalopathy (Acute hyperammonemic encephalopathy).

Case 6

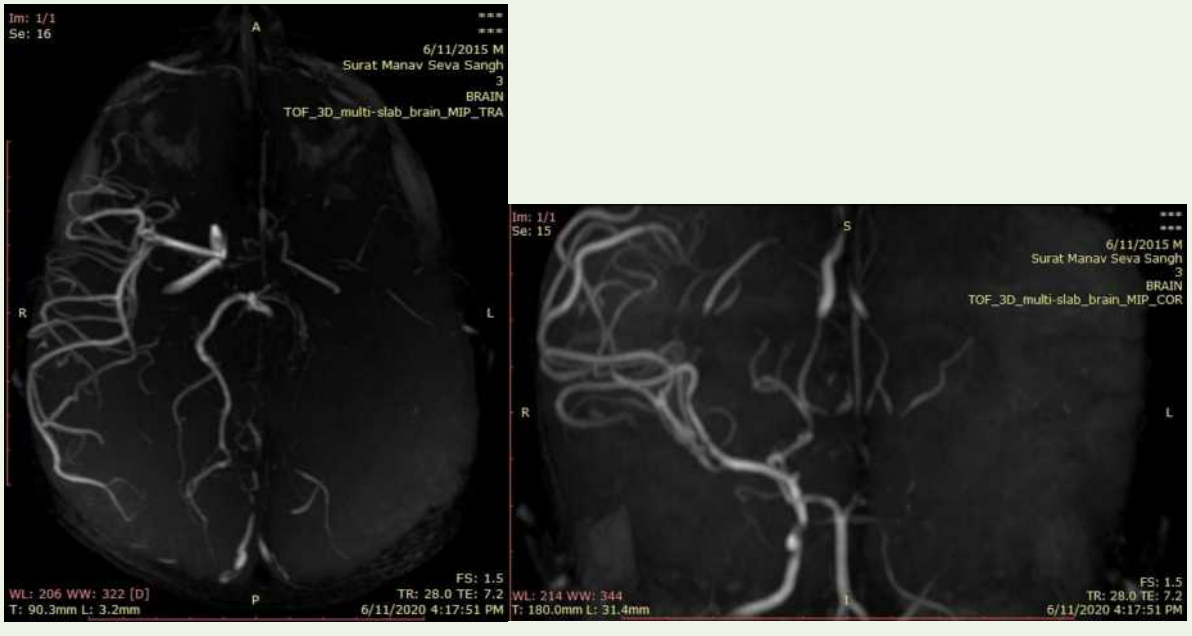
The child responded well to the supportive treatment for hyperammmonemia.

Discussion [2-6]

The clinical presentation in different pediatric neurological conditions is extremely various, depending on age, cause, and involved vascular territory, any metabolic abnormality associated Therefore the radiologiocal findings have to be clinically correlated for an accurate diagnosis.

The practical applications of DWI are in identifying regions and patterns of abnormal DWI signal and further characterizing them to low or high ADC's values.

The same finding of diffusion restriction in a patient with hemiparesis implies infarction. Conversely the same finding in a patient with seizures, fever could represent encephalitis spectrum, which includes both infective as well as auto-immune mediated. In a patient with systemic metabolic disorders (E.g hepatic dysfunction), the same finding would imply metabolic encephalopathy.



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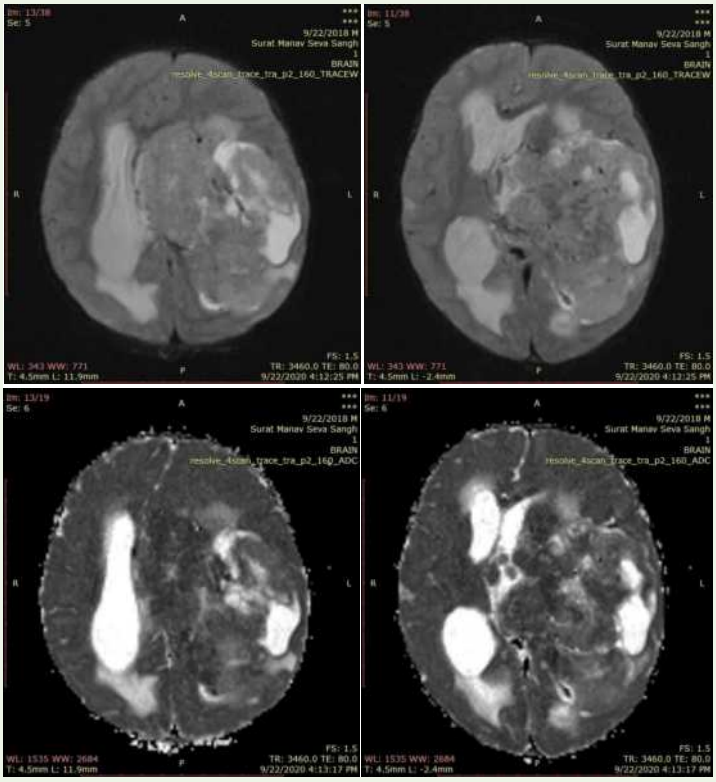
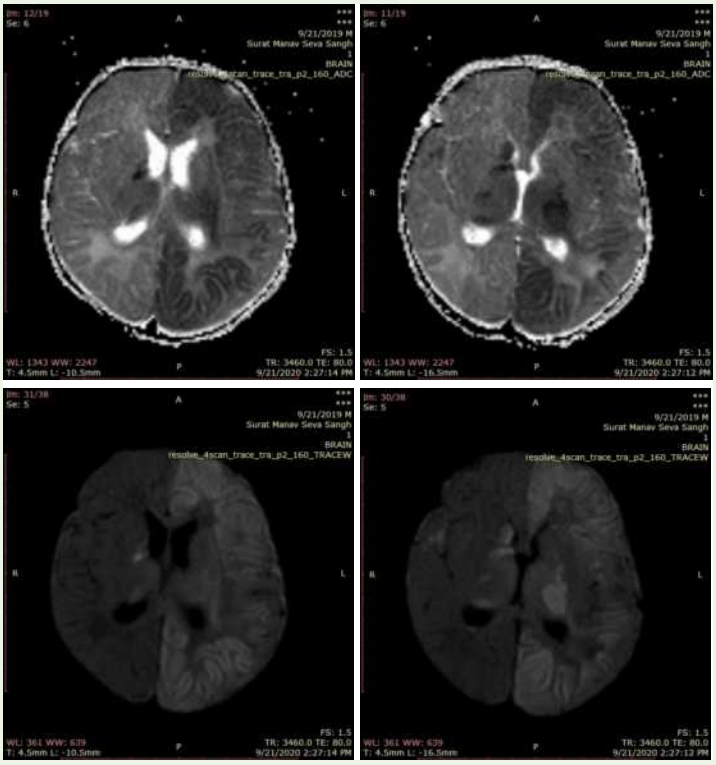


Case 3: Neoplastic etiology.



Case 4: Meningo-encephalitis spectrum.

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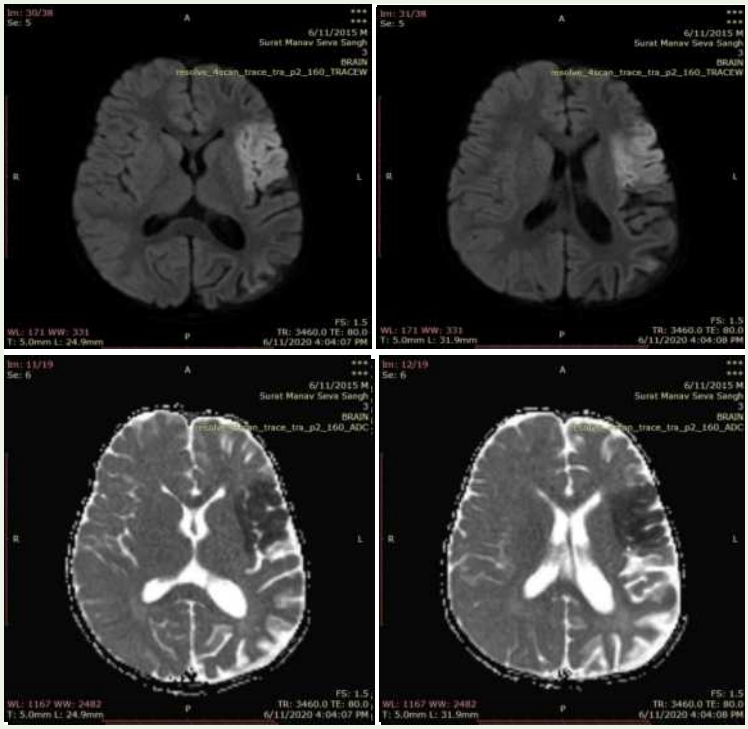
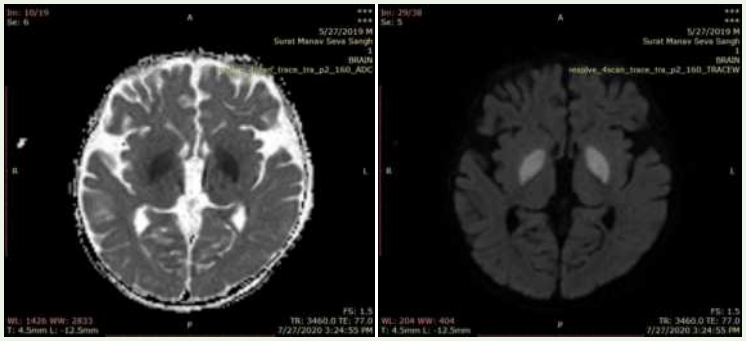


Case 5: Infarction spectrum.



Case 6: Metabolic spectrum.

Hematological/vascular disorders (like sickle, moya-moya) may present with stroke like picture with TOF-Angiography sequences showing the underlying etiopathology.

Among the pediatric strokes, embolic stroke tends to present suddenly, whereas thrombosis may have a more gradual onset. Focal neurologic deficits (cranial nerve palsies, hemiparesis, and hemisensory loss) are the most common presentation of AIS in children. Seizures, headache, language and speech difficulties, and altered mental status are also possible.

Based on these cases, it can be inferred that all the cases show more/less similar neuro-radiological picture on DWI-ADC imaging and therefore interpretation of all their differentials should be done in the clinical setting of presentation; All these cases are differential diagnosis to each other as far as the radiological picture is concerned;

Diffusion-Weighted Imaging (DWI) is a well-established technique in neuroimaging, but the diagnostic value of DWI outside the setting of acute infarct and abscess is sometimes under-recognised particularly in paediatric neuroimaging. DWI also plays an important role in the evaluation of intracranial infection, brain tumours, demyelinating diseases, and metabolic disorders.

DWI was more sensitive than the other MR sequences in detecting early pathological changes even in cases of viral encephalitis and leukodystrophy apart from ischemia. It was also helpful in delineating the area more accurately at the microscopic level.

Conclusion

Pediatric neuroradiological finding of diffusion restriction should therefore, be interpretated according to the clinical scenario of

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presentation, and in unison with the additional findings seen on other sequences such as GRE, T1-T2-FLAIR and post contrast sequences, to arrive at the final diagnosis.

The step-wise imaging algorithm for pediatric should be the diagnostic imaging paradigm with which radiologists and clinicians alike approach these patients. MRI is the initial modality of choice, including shortened stroke protocols (e.g. DWI, ADC, and SWI/GRE), followed by vascular imaging to detect abnormalities which may underlie an identified stroke.

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