

Review Article

MRI imaging in afebrile pediatric epilepsy: experience sharing

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ABSTRACT

In this article, we emphasize the usefulness and cost-effectiveness of non-contrast MRI as the primary imaging modality in the evaluation of non-febrile pediatric seizure, illustrate the MR spectrum of different structural lesions causing pediatric seizures, and finally describing the main MR imaging features of these disorders. Among 366 cases of pediatric epilepsy studied over a period of fifteen years the commonly detected structural malformations are mesial temporal sclerosis unilateral and bilateral, heterotopias, cortical dysplasia, neurocutaneous syndromes and few neoplasms. MRI showed hippocampal atrophy and increased signal intensity of the hippocampus on T2-weighted images in mesial temporal sclerosis, cortical thickness and sulcation are decreased in microcephaly, enlarged dysplastic cortex in hemimegalencephaly, and focal cortical dysplasia shows ipsilateral focal cortical thickening with radial hyperintense bands. MRI detects smooth brain in classic lissencephaly, the ectopic position of gray matter in heterotopias, and the nodular cortex with cobblestone cortex in congenital muscular dystrophy. MRI can detect polymicrogyria and the related syndromes, as well as schizencephaly types. In conclusion, MR imaging is essential to demonstrate the morphology, distribution, and extent of different disorders causing seizures in children as well as the associated anomalies and related syndromes to guide patient for further surgical treatment and counseling.

Keywords: Cortical dysplasia, Heterotopias, Mesial temporal sclerosis, Pediatric epilepsy, Tuberos sclerosis

INTRODUCTION

Epilepsy is a common neurological disorder in childhood and causes considerable anxiety in parents.¹ Cortical malformations are a major cause of developmental delay and drug-resistant epilepsy. These disorders are a heterogeneous group characterized by an abnormal structure of the cerebral cortex.²

Magnetic resonance imaging is the modality of choice to evaluate the structural anomaly, the cause of seizure disorder and to assess the potential need for surgery.

In this article, we are covering the spectrum of structural lesions detected in the evaluation of pediatric epilepsy

with stress on non-contrast MRI usefulness/cost effectiveness in comparison to contrast-enhanced CT.

The most common detected changes were unilateral and bilateral mesial temporal sclerosis, cortical dysplasia, migrational anomalies, neurocutaneous syndromes and range of cortical neoplasm as shown in the pictorial display.

OBSERVATION

We have retrospectively collected data of 366 patients with pediatric epilepsy who underwent MRI evaluation over a span of fifteen years. Exclusion criteria consist of a recent history of fever and clinical laboratory

parameters of any infective cause. The clinical presentation varied from focal seizures to a neurological deficit, fainting spells and generalized tonic-clonic seizures in some patients. Out of all patients scanned, 190 scans were normal i.e. without any MR discernible structural brain lesions (Table 1).

Table 1: Distribution of cases.

	No. of cases	Percentage
Normal	190	51.91%
U/L mesial temporal sclerosis	36	9.83%
B/L mesial temporal sclerosis	14	3.82%
Focal cortical dysplasia	21	5.73%
Hemimegalencephaly	4	1.09%
Lissencephaly	6	1.63%
Heterotopias	10	2.73%
Schizencephaly	8	2.18%
Tuberous sclerosis	73	19.94%
Cortical neoplasm	4	1.09%
Total	366	

Tuberous sclerosis is the commonest lesion detected in our study. The spectrum ranges from different varieties of gray matter heterotopias which were seen extending from the periventricular region, deep white matter up to subcortical white matter. Most of them show calcifications due to late presentation for evaluation. Images also illustrate cortical tubers and radial lines. One of the patients also had sub-ependymal giant cell astrocytoma.

Mesial temporal sclerosis is also one of the common lesions found in our study. It comprises approx. 14% of the total cases examined. Unilateral hippocampal atrophy is commoner than bilateral. Many of the cases were correlated well with EEG findings.

Malformation of Cortical development mainly focal cortical dysplasia, hemimegalencephaly, heterotopias, lissencephaly, and schizencephaly amount to approximately 13% of total patients.

We have also detected 4 cases of cortical neoplasm namely ganglioglioma, dysembryoplastic neuroepithelial tumor.

REVIEW OF LITERATURE

Multiple stages are involved in the assessment of a child with epilepsy, the most pivotal being clinical evaluation wherein the presence of actual seizures and its type is determined. Not all children require subsequent imaging. In those requiring further investigation, imaging studies could be structural or functional. MRI provides the best structural data, with nuclear medicine and specialized MR techniques giving supportive information of the

function. CT now has a much-diminished role.³ This review highlights the role of MR in the investigation of childhood epilepsy, as well as spectrum. We believe that the article will help both the physician and the general radiologist in referring the patient for a clear-cut investigation and plan the treatment.

MESIAL TEMPORAL SCLEROSIS (MTS)

Mesial temporal sclerosis refers to the formation of an epileptogenic focus due to neuronal loss and gliosis of the hippocampus.⁴

Other than having a strong association with complex partial seizures (60-85% cases), MTS is also known to be the most common structural abnormality in human epilepsy.^{5,6}

The two primary MRI findings include hippocampal atrophy which is recognized by asymmetry in the case of unilateral atrophy and increased signal intensity of the hippocampus on T2-weighted images (Figure 1).⁷

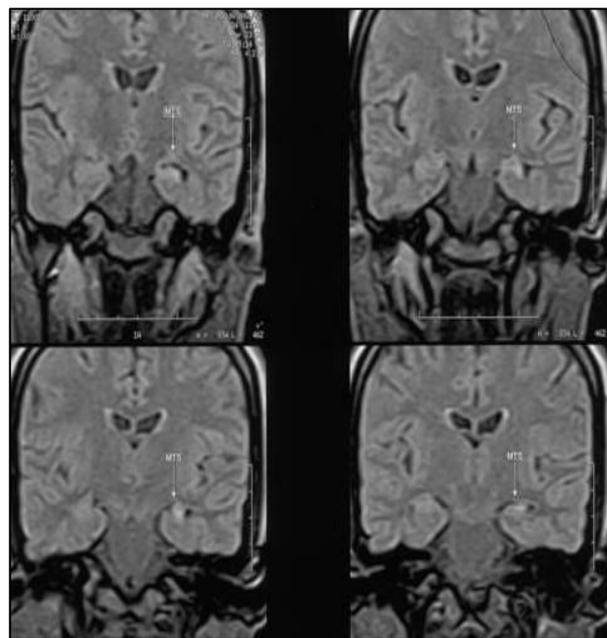


Figure 1: Mesial temporal sclerosis in 7 year female. FLAIR coronal images show loss of volume of left hippocampus with T2/FLAIR hyper intensity.

Secondary MR features suggesting MTS include temporal horn dilatation, loss of hippocampal signal on T1WI, loss of hippocampal head digitations, loss of commissural white matter and poor parahippocampal gray-white matter definition.⁸⁻¹¹

There could be associated ipsilateral atrophy of the temporal lobe, thalamus, and fornix and mamillary body. Quantitative volumetric (3D SPGR) imaging increases sensitivity for MTS detection, particularly in bilateral involvement.¹²

MALFORMATION OF CORTICAL DEVELOPMENT

Focal cortical dysplasia (FCD)

FCD is a localized region of the cerebral cortex formed by abnormal neurons and glial cells. FCD Type II is known to be one of the leading causes of epilepsy, both in children and in adults.¹³ Most often located in the central and precentral cortex. Managed routinely by surgical resection.¹⁴

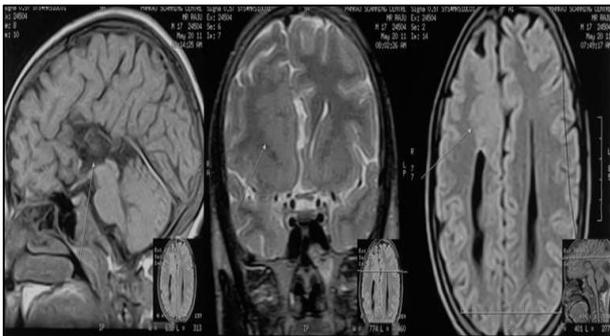


Figure 2: Corpus callosal agenesis with focal cortical dysplasia in 12 years male. Sagittal T1W, coronal T2W, axial FLAIR images show focal cortical thickening and expanded gyri at right parafalcine cortex. Note is made of absent corpus callosum; parall.

On MRI, it appears as areas of cortical thickening with an indistinct gray-white matter junction. There also occur areas of abnormal signal intensity extending from the gray-white matter junction to margin of the lateral ventricle. These foci show high signal intensity on T2-weighted images and low signal intensity on T1-weighted images (Figure 2 and 3).¹⁵

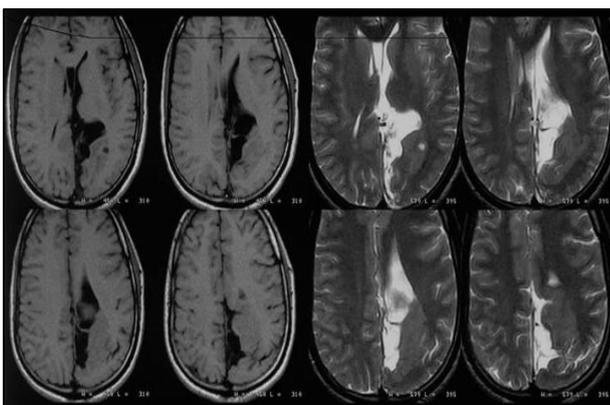


Figure 3: Dysplastic heterotopic cortex with interhemispheric cyst in 10 years male. T1W and T2W axial images show heterotopic gray matter abutting left paramedian interhemispheric cyst.

Other findings include macrogyria and abnormally widened or deep sulci. In some patients, a linear or curvilinear focus of abnormal signal intensity extends

from the cortical-white matter junction to the ventricular surface this is referred to as the trans mantle sign and appears to be unique for FCD Type II when seen.¹⁶ Anomalous draining vein or CSF cleft associated with cortical dimple may suggest an underlying dysplasia.

Hemimegalencephaly

Hemimegalencephaly is the enlarged and dysplastic hamartomatous overgrowth of part or all of the cerebral hemisphere. There is moderate-to-marked enlargement of complete or part of a cerebral hemisphere, which can be normal or dysplastic.¹⁷ Gray white matter junction appears indistinct. The gyral pattern may turn up grossly normal or may be frankly agyric or polymicrogyric (Figure 4).¹⁸ Heterotopia and astrocytosis will show variable degrees of abnormal T1 and T2 prolongation of the white matter. The enlarged lateral ventricles showed a characteristic shape of the frontal horns that appears straight and pointed anteriorly and superiorly.

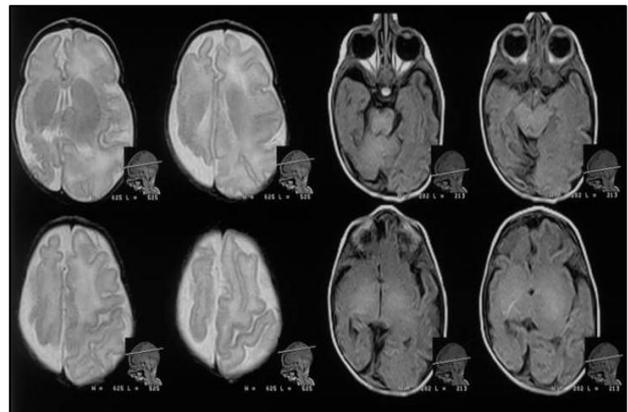


Figure 4: Hemimegalencephaly in 2 years male; T1W and T2W axial images show marked enlargement of left hemisphere with broad thick sulci; heterogeneously hyperintense white matter.

Classic (type I) lissencephaly

It occurs in two forms. The "complete" form will show complete agyria whereas the "incomplete" forms have parietooccipital agyria with frontotemporal pachygyria. There will be a loss of gray-white matter differentiation with cortical thickening and thin subcortical white matter. T2-weighted MR image may show a peripheral band of high signal intensity, commonly in the parietooccipital cortex. Cerebral configuration is oval or an hourglass with shallow Sylvian fissures due to lack of or incomplete operculization.¹⁹⁻²¹

Cobblestone (type II) lissencephaly

In cobblestone lissencephaly, the patient will have nodular brain surface, ocular anomalies, and congenital muscular disorders.²²

Heterotopia

Heterotopia defines as collections of normal neurons located in unusual locations, anywhere from the subependymal region to the cerebral cortex. There may be associated pachygyria, agenesis of the corpus callosum, Chiari II malformation, arachnoid cyst, schizencephaly, and cephalocele.

Periventricular (subependymal) heterotopias

These about the ventricular wall. Most common location is trigone and occipital horns of the lateral ventricles. They are usually bilateral with a predilection for the right cerebral hemisphere. On MRI, they appear as round-to-oval nodules, isointense to the cortex on all pulse sequences, with no post-contrast enhancement (Figure 5).²³

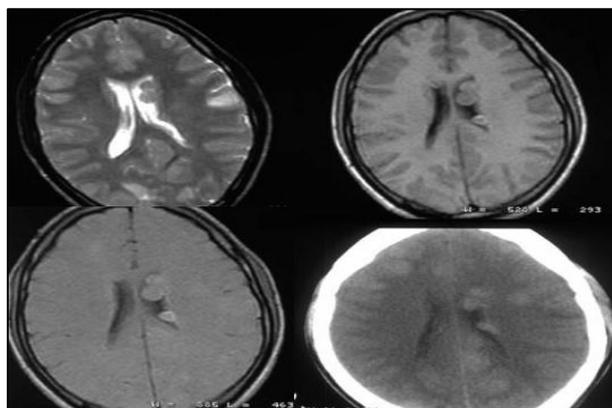


Figure 5: Heterotopias in 15 year male. T2W, T1W, FLAIR axial, T2W Sagittal and NECT axial images show nodules of heterotopic gray matter protruding into the left lateral ventricle.

Subcortical heterotopias

They may be involving the subcortical or deep white matter. The overlying cortex appears thin with shallow sulci. The affected hemisphere may decrease in size. SCH may have a nodular, curvilinear, or mixed form.²⁴

MR spectroscopy can differentiate heterotopia from a low-grade glioma. Heterotopia will show metabolites similar to those of normal brain parenchyma. Low-grade gliomas will show a decrease of N-acetyl-aspartate and increase of choline peak.^{25,26}

Band (laminar) heterotopia

It is due to an early arrest of neuronal migration. Band heterotopia will have a smooth layer of the gray matter that often follows the curvature of the overlying cortex. On MR imaging, it shows the typical 3-layer cake (continuous double cortex) in which there is an interposition of thin white matter band between the cortex

and the subcortical layer of band heterotopias. The cortex may be relatively normal or pachygyria.²⁷

Schizencephaly

Schizencephaly appears as a CSF-filled cleft which extends medially from the subarachnoid space to ventricular system. Dysmorphic gray matter lines the wall of the cleft. The cleft may be small or large, unilateral or bilateral. The gray matter may extend to the lateral ventricle as subependymal heterotopia. The anomaly may be of the open-lip or closed-lip type. Closed-lip schizencephaly has gray matter lined lips, which are in contact with each other. Open-lip schizencephaly will have separated lips and a cleft of CSF extending to the underlying ventricles (Figure 6). It may show association with optic nerve hypoplasia, septo-optic dysplasia, absent septum pellucidum, pachygyria, PMG, heterotopia, and arachnoid cysts.²⁸

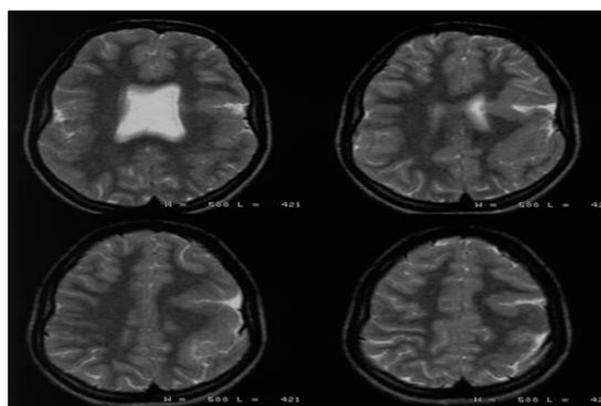


Figure 6: Left open lip schizencephaly in 14 year female. T2w axial images show dysplastic gray matter lined CSF filled cleft with absent septum pellucidum.

TUBEROUS SCLEROSIS

Salient features of TSC are cortical tubers, white matter radial migration lines, subependymal nodules and subependymal giant cell astrocytomas.

Tubers

The cerebrum is the most common location of tubers, predominantly (90%) in the frontal lobes. Tubers typically appear as areas of increased signal intensity in the cortical and subcortical regions on T2-weighted and FLAIR MR images. 3-4% of tubers may show contrast enhancement. The majority of tubers are multiple in numbers. Unlike cortical tubers, cerebellar tubers are usually wedge-shaped and not epileptogenic. Tubers are rare in the brainstem and spinal cord.^{29,30}

Subependymal nodules

These are areas of confluent hypertrophic tissue located at the walls of lateral ventricles. Though caudothalamic

groove in the region of the foramen of Monro is the most common location of these nodules, they can occur anywhere along the ventricular surface. Typically benign, subependymal nodules can degenerate into subependymal giant cell astrocytomas in 5-10% of cases. Like subependymal giant cell astrocytomas, subependymal nodules can also enhance with contrast material.

Subependymal giant cell astrocytoma

Subependymal giant cell astrocytomas grow in an indolent manner which results in ventricular obstruction and hydrocephalus.

Radial migration lines

These lines are primarily located in the subcortical white matter and are sometimes in association with tubers. They occur along expected path of cortical migration and represents heterotopic glia and neurons.³¹

Microcephaly

A patient suffering from tuberous sclerosis has been found to have decreased cerebral gray and white matter volume than those of age-matched controls. Statistically, significant microcephaly is seen in both TSC patients with and those without a history of epilepsy.³²

CORTICAL NEOPLASM

The superficial cerebral gliomas are important because of various underdescribed features. They tend to manifest in younger patients with refractory seizures and resection of these tumors is often curative. The majority of them are graded as WHO grade I tumors except pleomorphic xanthoastrocytoma. Characteristic imaging features include involvement of the cortical gray matter, soft-tissue and cystic components, and enhancement of the soft tissue portion of the mass (Figure7).

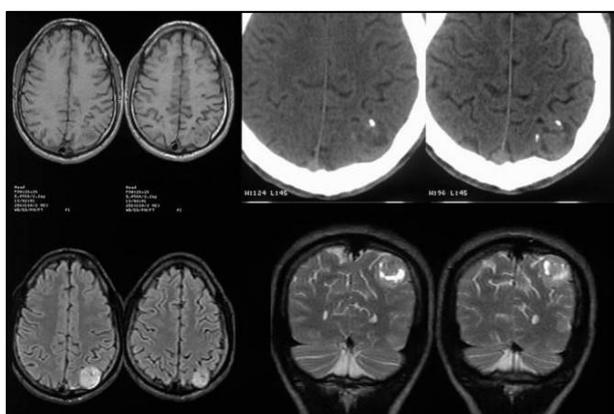


Figure 7: Cortical neoplasm in 1 year male. TIW, FLAIR axial and T2W coronal images show cortical based T2 FLAIR hyperintense lesion.

Dysembryoplastic neuroepithelial tumor

The temporal lobe is the most common site (62%), followed by the frontal lobe (31%). The majority of dysembryoplastic neuroepithelial tumors confines to the cortical gray matter, but may also arise within the caudate nucleus, cerebellum, or pons.

At MR imaging, DNET most commonly seen as cortical masses that are T1-hypointense and T2-hyperintense with no perifocal vasogenic edema. Some lesions may appear as a bulky gyrus, producing a soap-bubble appearance at the cortical margin. About one-third of dysembryoplastic neuroepithelial tumors enhances following intravenous administration of contrast material.³³

CONCLUSION

MR imaging is a valuable tool for the diagnosis of disorders of cortical malformation and others disorders. It helps in demonstrating the morphology, distribution, and extent of cortical disorders. Moreover, it can identify the associated congenital anomalies and related syndromes. MRI in today's world plays a deciding role in diagnostic work-up of a child with epilepsy.

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