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Role of Neuroimaging in Paediatric Seizures

[1]Dr. E. Sridurga.E, [2]Dr. G. Balachandiran
[1]Post Graduate, [2]Professor,
Department of Radiology, Rajah Muthiah Medical College and Hospital, Chidambaram

***Corresponding Author:**
Dr. E. Sridurga.E
Post Graduate, Department of Radiology, Rajah Muthiah Medical College and Hospital, Chidambaram

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Abstract

Background: Seizures are most common in the paediatric age group .In order to effectively manage a child with seizure it is essential to identify the cause. This study aims at identifying the intracranial structural abnormalities through neuroimaging in children from birth to 12 years. In this study we also aim at identifying the most common aetiology for seizures in this region.

Methods: This is a prospective study in 94 children from birth to 12 years presenting with seizure and referred from the department of Paediatrics between September 2019 to July 2021. All patients underwent at-least one form of neuroimaging. Among the 94 children, 23 patients had CT examination, 72 patients had MRI scanning and 31 patients had neurosonogram. 15 patients had both CT and MRI, 16 patients had both neurosonogram and MRI.1 patient had CT and neurosonogram.

Results: 57 (60.6 %) patients revealed abnormal imaging of significance and 37 (39.4%) patients revealed normal study. The most common imaging findings in our study was CNS tuberculosis (10.6%) which included tuberculomas (4.25%), post Tuberculosis hydrocephalus(4.25%) and Tb meningitis (2.1%). The next most common aetiologies were Gliosis with or without encephalomalacia which contributed 7.4%, CVA contributed 7.4%, HIE contributed 6.3%, arachnoid cyst and neurocysticercosis contributing 4.25% each. Other cases were cerebral atrophy, Encephalitis, Calcified granuloma, porencephaly, Dandy Walker malformation, Band heterotopia, Vander knap disease, Sandhoff's disease, lissencephaly, congenital TORCH and cerebral abscess.

Conclusion: Paediatric age-group is a crucial period in the life of a child. Hence it is important to identify the aetiology of seizure at the earliest to help in timely management. Early and accurate diagnosis helps in proper treatment and better prognosis.

Keywords: Paediatric seizure, neurosonogram, CT, MRI, intracranial structural abnormalities

Introduction

Seizure is an episode of neurological dysfunction caused by abnormal neuronal activity that leads to a sudden change in motor activity, behaviour or sensory perception. The clinical spectrum of seizures includes focal or partial seizures and generalized seizures. (1)

Seizure is an emergency in children and is a very common cause for hospitalization of children and it results in significant mortality and morbidity. There are very few studies done on neuroimaging in seizures from developing countries like India. Most studies conducted till now have focused on clinical aspect of seizures. Dedicated studies in paediatric population using neuroimaging have been even fewer till date in India.(2)

It is presently recognized that epilepsy is usually related to gross or subtle structural or metabolic lesions of the brain. The rationale in clinical practice

for the utilization of neuroimaging in epilepsy is to spot pathologies like granulomas, malformations, vascular or traumatic lesions, tumors, etc. that require specific treatment; and also help in the formulation of syndromic and etiological diagnoses so as to give patients and their relatives an accurate prognosis.[3]

This study is to evaluate the structural abnormalities in brain with the help of Neurosonogram/CT/MRI and arrive at an accurate etiological diagnosis. This helps in determining the treatment protocol, early intervention and prevention of complications in the patient. Early detection and institution of prompt remedial measures leads to favourable prognosis.

METHODS:

A prospective study was done in the study population which included 94 children both in and out patients of Rajah Muthiah Medical College, from the age group birth to 12 years who are referred for neurosonogram /CT scan / MRI of brain with history of unprovoked seizures. Neuroimaging was done on the advice of the referring doctor The Study group was further sub divided into 4 groups -Neonate(from birth to 28 days), Infants (28 days to 1 year), Preschool age 2-5 years and School age 6-12 years

We also excluded patients presenting with seizures following acute antecedent events like toxicity and poisoning and those not willing to undergo the study. Among the 94 children, 23 patients had CT examination, 72 patients had MRI scanning and 31 patients had neurosonogram. 15 patients had both CT and MRI, 16 patients had both neurosonogram and MRI.1 patient had CT and neurosonogram. Contrast procedure was done as per the indication after reviewing the plain study.

DISCUSSION:

In age distribution, Neonate (from birth to 28 days) accounted 13.8% (13/94). Infants (28 days to 1 year) accounted 32.9% (31/94). Preschool age 2-5 years accounted 30.9% (29/94). School age 6-12 years accounted 22.3% (21/94) (fig.1)

The total number of boys in the study are 59 and were 62.8%, girls were 35 in number and 37.2%. (Fig.2). A Slight male preponderance was noted with male to female ratio of 1.6:1

57.4% patients presented with only complaints of seizure, 11.7% patients presented with associated fever and 7.4% patients presented with associated fever, altered sensorium and vomiting (Fig.3)

In our study generalized tonic clonic seizures accounted 70.2 %(66 patients), focal seizures accounted for about 29.8% (28 patients) (Fig-4)

This is in agreement with other studies in Africa [4] and India [5], showing preponderance of GTCS of 60-90% [6]

Neuroimaging abnormalities were found in 66% (44/66) of generalized seizures (Fig-5), and 46.4% (13/28) of focal and multifocal seizures had neuroimaging abnormalities. Normal neuroimaging study was found in 33% (22/66) of patients with GTCS and 53.5% (15/28) of patients with Focal seizures.

A positive family history was observed in 10.6%(10/94) cases and 89.4% (84/94) patients had no significant family history(Fig.5). Most types of epilepsy have a weak genetic component and the presence of a family history increases the risk of an affected child. While predominantly genetic epilepsies constitute a minority of all seizure disorders, the etiology of epilepsy combines acquired and genetic factors.[7]

A significant past history of seizures was seen in 43.6% (41/94) patients and negative past history was noted in 56.4% (53/94) patients. (Fig.6) Among the 94 patients, 79.7% (75) children were developmentally normal and 20.2% [8] children showed developmental delay.(Fig.7)

MRI was done in 72 patients and We found positive MRI study in 61.1% cases. Resta et al. [9] reported positive MRI in 51.3%, Wang et al. [10] in 41.7% and Chang et al [8] in 48.9%. Our study shows a higher percentage, probably because of strict exclusion criteria's, which shows that patient selection, plays an important role in MR positivity rates.

MRI helped us to differentiate neurocysticercosis and tuberculomas. MRI study clearly delineated metabolic, neurodegenerative, and neurocutaneous disorders.

CT scan was done in 23 patients, of which 11(47.8%) showed normal CT scan, 2 had significant MRI findings which were not seen on CT scan. Conversely patients who were found normal on MRI were normal on CT. This difference in diagnostic ability of

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CT and MRI was shown by previous studies also.[11,12] This could be reasonably explained by multiplanar imaging capability, improved contrast of soft tissue, and high anatomical resolution of MRI over CT. Our finding corresponds with Jackson et al, 2006 [13], that it could be reasonable to forego CT and perform MRI. MRI is useful in the diagnosis of vascular malformations such as cavernomas. It produces images in various planes and sequences that aid the characterization of the lesion. There is no risk of radiation to the patient, and hence very useful in pediatric age groups

The present study showed that the maximum cases belonged to 28 days to 1year of age-group (32.9% of total sample population) but positive MRI findings were more in 2-5 year age group. Children in 2-5 year age group were 30.9% of total sample and MRI positivity was seen in 38.6%. In the incidence and prevalence studies carried out in India, it was higher in first decade of life.[14,15] Our findings correspond with this study

The most common cause of epilepsy in our study was CNS infections in this region, being at 19%.CNS tuberculosis contributed to 10.6% (10/94),of which Tuberculomas contributed 4.25%(4/94), Post Tubercular Hydrocephalus contributed 4.25% (4/94) of the total cases,tubercular meningitis contributed 2.1%(2/94). This was followed by Neurocysticercosis which contributed 4.25%(4/94) of the total case, encephalitis which contributed 2.1% (2/94), calcified granuloma in 2.1%(2/94) TORCH infection in 1% (1/94) and cerebral abscess 1% (1/94) . Neuroimaging usually confirms the diagnosis by revealing a typically ring enhancing lesion on contrast CT or MRI.[16]This correlates well with studies done in other tropical countries, where infection still predominate as the most common cause of epilepsy.[17] In the studies conducted in other developing countries like Africa [4] and Nigeria [18] also similar finding has been reported. This could be due to the poor sanitation and low socio-economic status, still persisting in the developing countries. On the contrary, The studies in developed countries showed that the most common cause for epilepsy, were cerebral dysgenesis[12] and followed by hypoxic-ischemic lesions, non- accidental injuries, infections, metabolic diseases and tumours.[8]

Most cases of the encephalitis are caused by arboviruses demonstrating regional and seasonal variation. Viral encephalitides are found all over the world with specific viruses being common in different geographical regions.[19]

Gliosis with or without encephalomalacia, periventricular leukomalacia, porencephaly and cortical atrophy are the varying response of brain to any type of prior insult, mostly in theperinatal stage or in the stage of infancy, but can occur later due to trauma, infection, infarct or hemorrhage. The result of insult during perinatal period depends upon the gestational age of patient, duration and severity of brain insult along with prenatal asphyxia, low birth weight, prematurity and toxaemia of pregnancy as predisposing factors.[20]Those patients with perinatal insult usually presented with cerebral palsy, intractable seizures and developmental delay.

In our present study, 7.4% (7/94) cases showed encephalomalacia with /without gliosis, 3.1% (3/94) cases showed cerebral atrophy, 2.1%(2/94) patient had porencephaly. Porencephalic cysts are congenital or acquired cavities within the cerebral hemisphere that usually-although not invariably - communicate directly with the ventricular system. They can be cortical or subcortical, unilateral or bilateral.[21] The location often corresponds to territories supplied by the cerebral arteries.

Findings pertaining to HIE were seen in 6.3% (6/94) cases. Out of which 3 were preterm and 3 were term babies.The various patterns noted were Germinal matrix hemorrhage, periventricular leukomalacia and echogenicity in splenium of corpus callosum. Periventricular leukomalacia, represents toxic injury to premyelinating oligodendrocytes because of cerebral ischemia, reperfusion, or both.[20,22] Since white matter does not have a generous blood supply as gray matter and is more susceptible to ischemia (HIE, vasculitis secondary to infection), toxin and other insults.[23] The most common location for the hyperintensities are the subcortical and periventricular white matter, optic radiations, basal ganglia and brain stem, in decreasing order of frequency. The lesions are hyperintense on T2, proton density, and FLAIR images and have well-defined but irregular margins.

Vascular diseases of the paediatric age group include haemorrhage, venous thrombosis, and arterial

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infarctions. Cerebrovascuar accident contributed 7.4 % (7/94). Out of whichInfarct contributed to 3.1% (3/94) cases in our study. Intra-axial bleed and extra axial bleed was seen in 4.2% patients (4/94). There is no prior record of how much they account for epilepsy, but they do cause epilepsy in paediatric age group. In contrast to stroke in adults and older children, neonatal stroke often presents clinically with seizures but not with focal neurological deficiencies.[24]Children can present stroke at any age. The incidence is higher under the age of 2 years and progressively decreases throughout adolescence.[25] We also foundneonates/infants in the present series during the investigation. The common causes of strokes in children are Rheumatic disease, Infectious endocarditis, congenital heart disease, mitral valve prolapse, sickle cell disease, haemolytic uremic syndrome and Antiphospholipid antibody syndrome. In many cases cause could not be determined.[26] Here We report 1 case of head traumawho had more than one episode of seizure following traumatic brain injury (TBI). Seizures are usually an indication of a more severe TBI. Seizures that occur shortly after a person suffers a brain injury may further damage the already vulnerable brain.[27]

Congenital structural defects constituted 10.6% (10/94) of imaging findings. Out of which arachnoid cyst accounted for 4.2% (4/94), Cerebellar malformations (Dandy-walker malformation) accounted 2.1% (2/94), Lissencephaly 1% (1/94), Heterotopia 1% (1/94), Van der knaap disease 1% (1/94) and Sandhoff's disease 1% (1/94) of neuroimaging findings. Diagnosis of Metabolic disorders made with metabolic workup along with MRI imaging of brain. The case of heterotopia was subcortical band heterotopia in nature and patient presented with epilepsy. Malformations of cerebral cortical development encompass a heterogeneous group of disorders frequently recognized on magnetic resonance images (MRI). These types of disorders are a cause of human epilepsy.[28]

RESULTS:

Out of the 94 patients belonging to age group 0 to 12 years and who were clinically diagnosed with epilepsy, 59 (62.8%) were males and 35 (37.2%) were females. The maximum number of children under study belonged to the age group 2-5 years (30.9%) but the maximum case positivity which means children with structural abnormalities belonged to 6-12 year age group. 57 of the 94 patients (60.6 %) revealed abnormal imaging of significance and 37 out of 94 patients (39.4%) revealed normal study. The most common imaging findings in or study was CNS tuberculosis (10.6%) which included tuberculomas (4.25%), post Tuberculosis hydrocephalus(4.25%) and Tb meningitis (2.1%). The next most common etiologies were Gliosis with or without encephalomalacia which contributed 7.4%, CVA contributed 7.4%, HIE contributed 6.3%, arachnoid cyst and neurocysticercosis contributing 4.25% each. Other cases in decreasing order of frequency were 3.1% cases of cerebral atrophy followed by 2.1% each of Encephalitis, Calcified granuloma, porencephaly, Dandy Walker malformation. Rest of the cases contributed only 1% each. Such uncommon findings were Band heterotopia, Vander knap disease, Sandhoff's disease, lissencephaly, congenital TORCH and cerebral abscess.

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Fig.1 CT FINDINGS

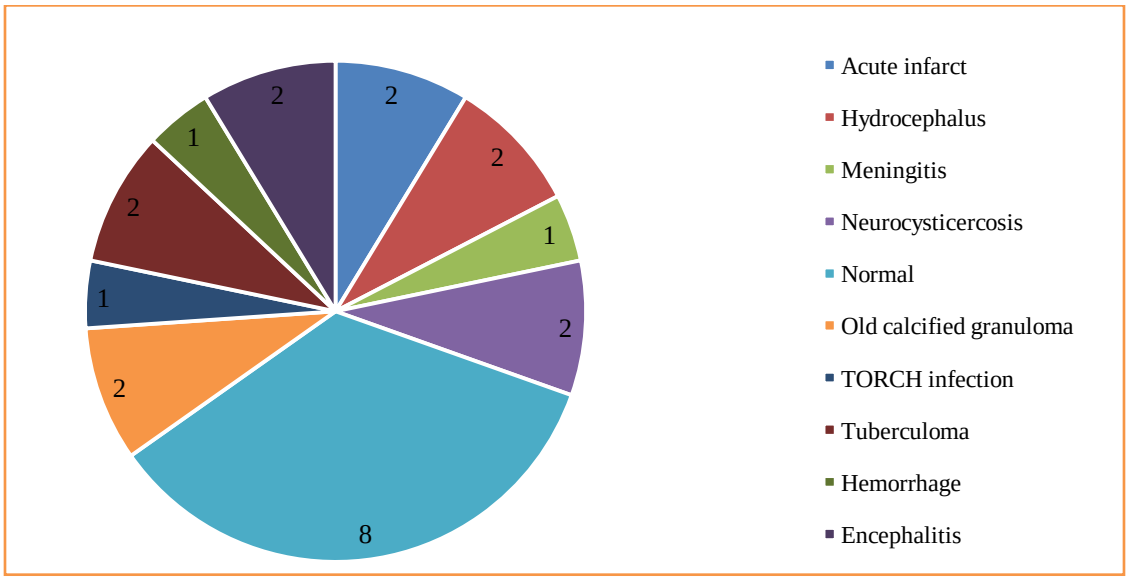

Fig.2 MRI FINDINGS

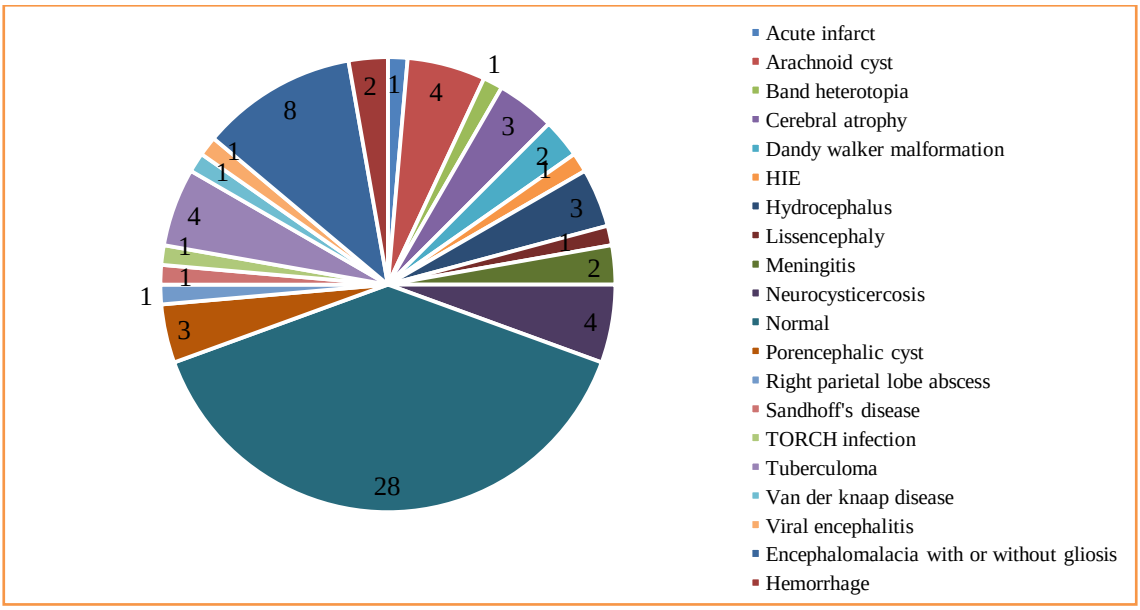

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Fig.3 NEUROSONOGRAM FINDINGS

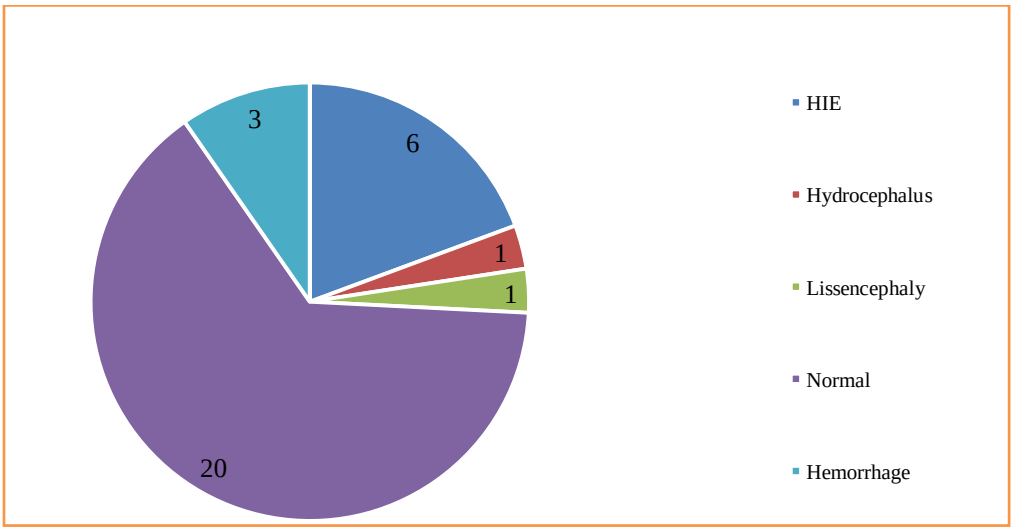
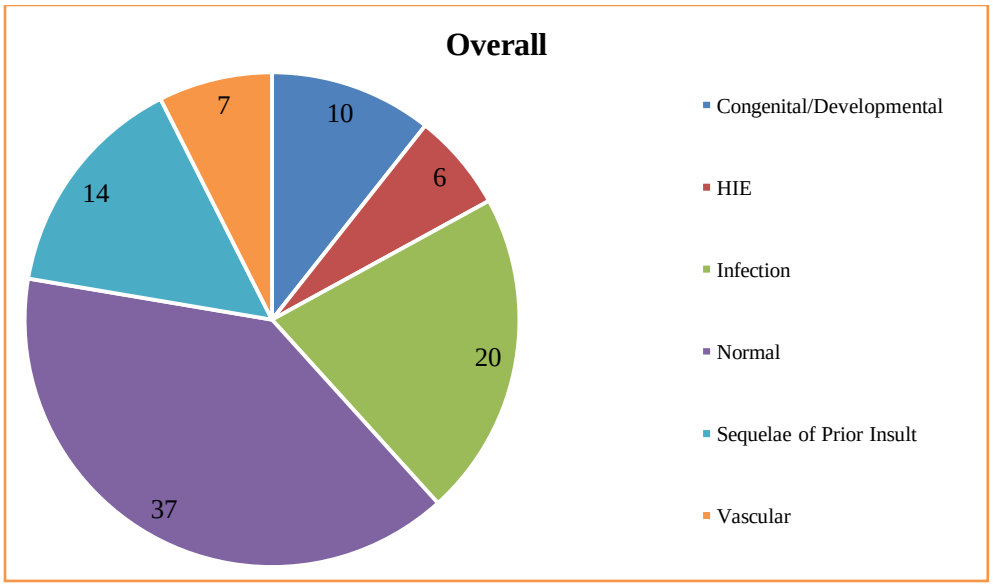


Fig.4 ETIOLOGY OF SEIZURES OVERVIEW



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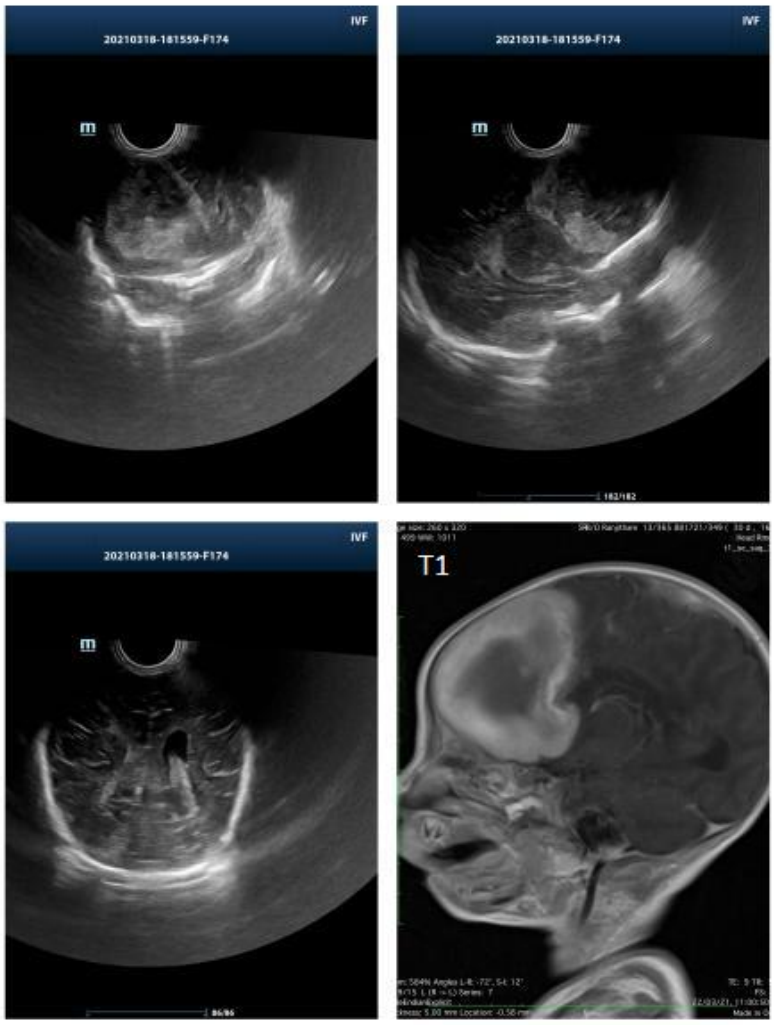

Fig. 5 Neurosonogram and MRI depicting acute intraparenchymal haemorrhage with intraventricular extension on the right and subdural haemorrhage in the right frontoparietal lobe

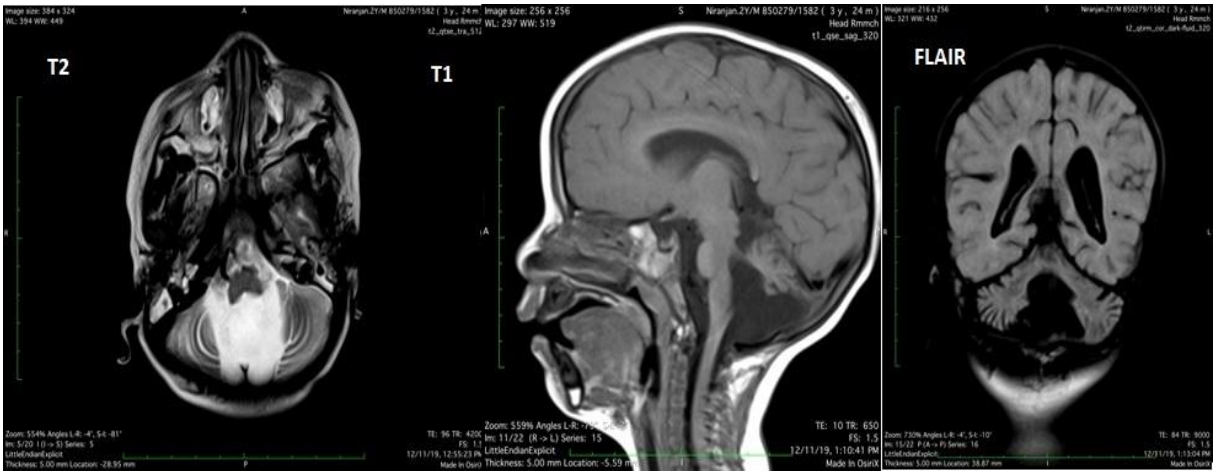

Fig.6 MRI images depicting DANDY WALKER MALFORMATION

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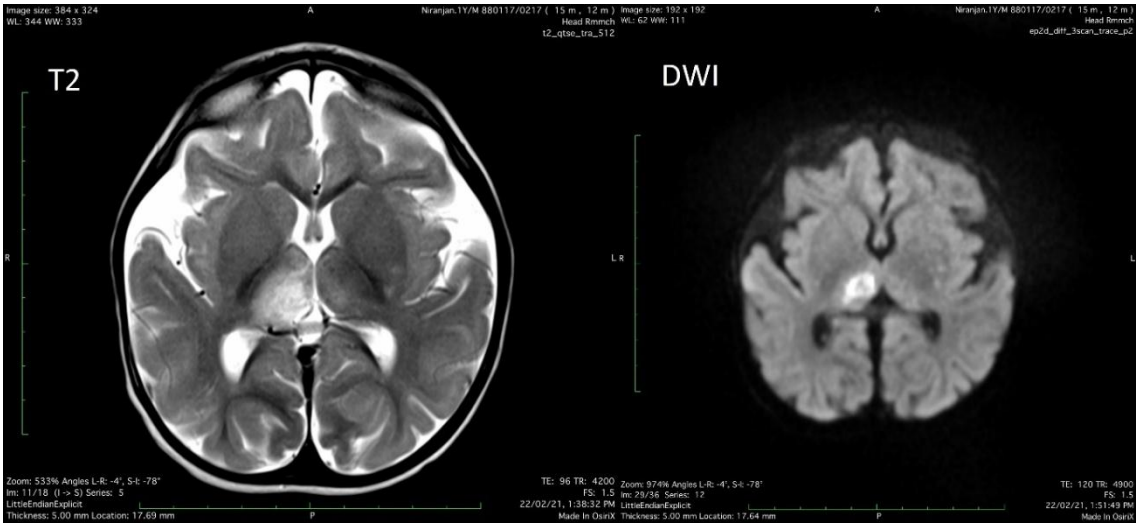

Fig.7MRI depicting acute infarct in right thalamus

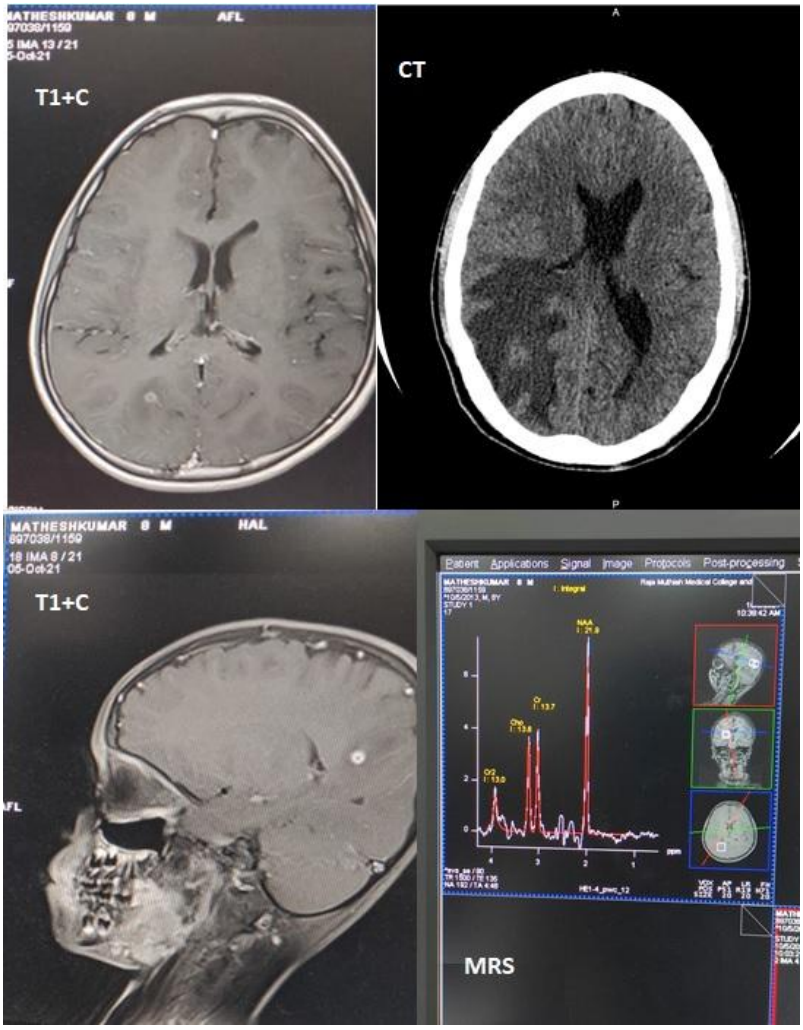

Fig.8 shows the CT brain image taken a year back and the recent MRI with MRS images depicting Neurocysticercosis in the right parietal lobe

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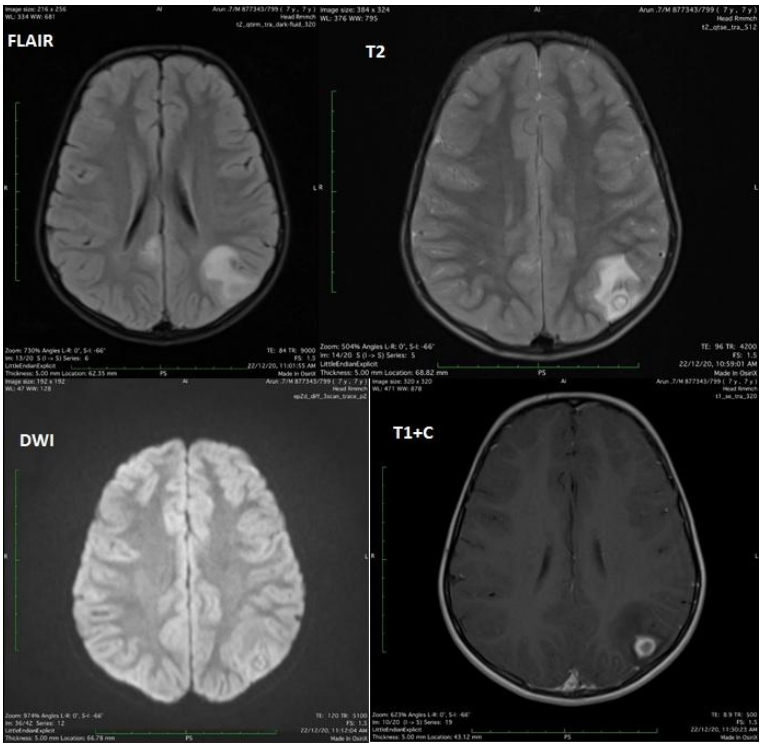

Fig.9 MRI images depicting a case of tuberculoma in left parietal lobe

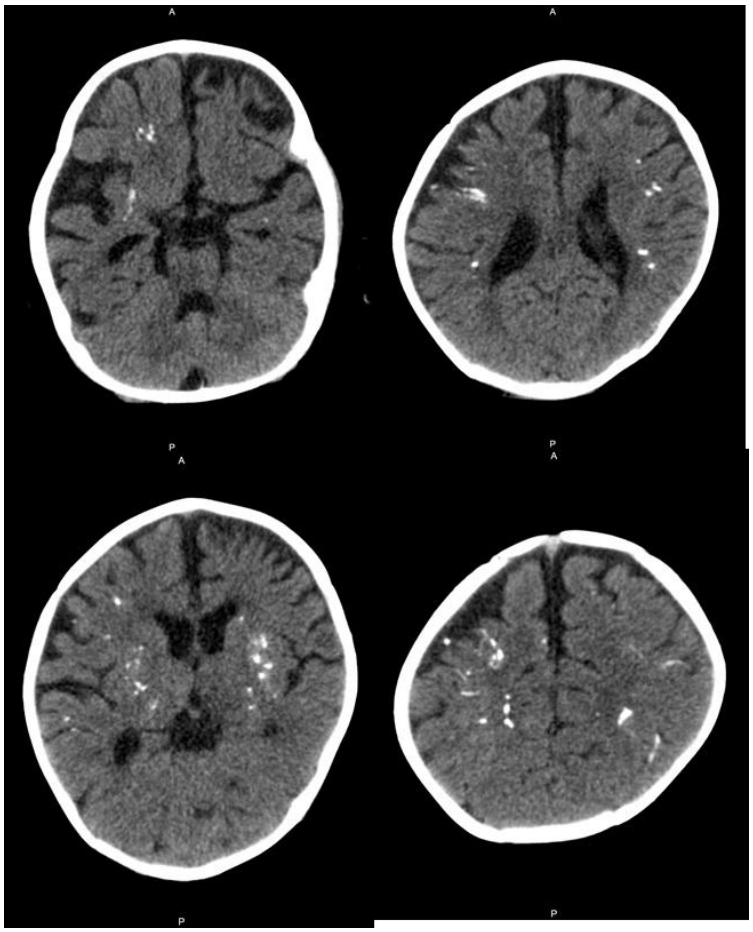

Fig.10 CT scan depicting multifocal intracranial calcifications -TORCH infection

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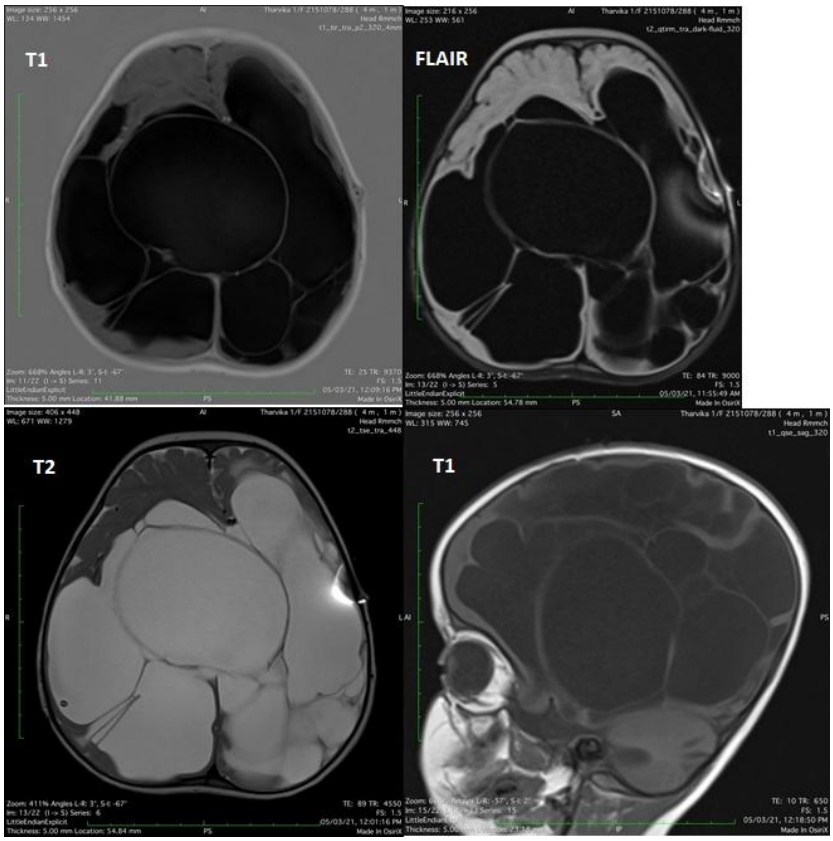

Fig.11 MRI depicting multiple cystic lesions replacing brain parenchyma – Porencephaly

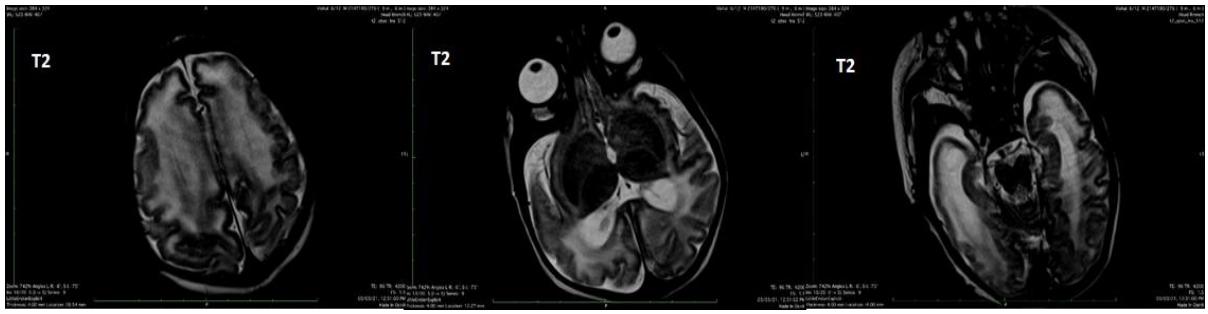

Fig.12 depicting Megalencephalic leukoencephalopathy with subcortical cysts/ Van der knap disease.

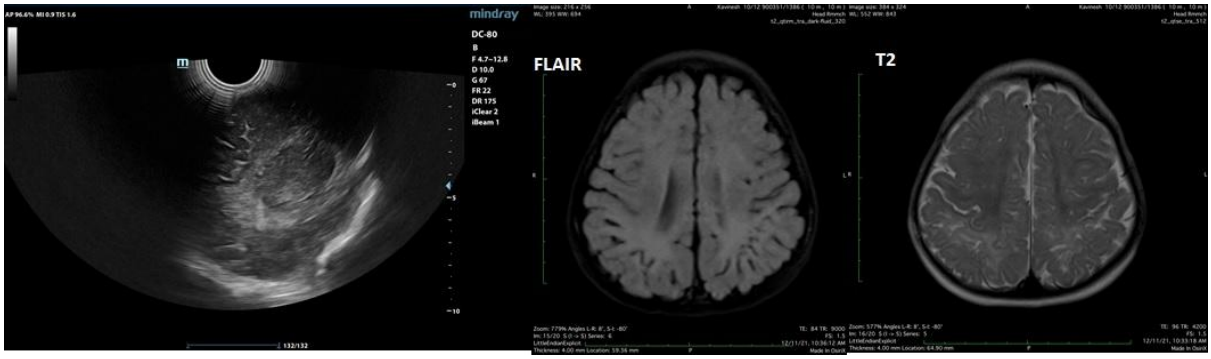

Fig.13 Neurosonogram and MRI depicting HIE changes

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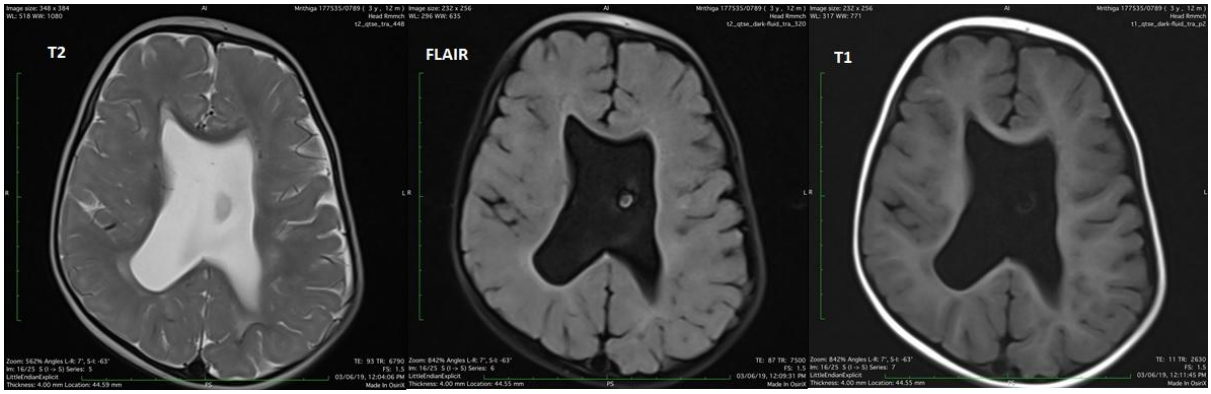

Fig.14 MRI images depicting intraventricular neurocysticercosis with absent septum pellucidum

Conclusion

The commonest aetiology of seizures is CNS infections which includes CNS tuberculosis, neurocysticercosis and other infections. It accounted for almost 19% of cases of seizures in present study. The various neuroimaging techniques when combined with the acquisition of proper clinical history helps in the accurate diagnosis in these cases which when treated at the appropriate time saves the patient from progressing and complicating due to the infection. Appropriate neuroimaging technique has helped in treating these cases at the right time.

Paediatric age-group is the most common period for seizures and this is a crucial period in the life of a child for the physical, mental and social development. Hence identifying the aetiology at this stage is essential in the growth and development of the child and in timely management. Our approach of using 3 modalities of neuroimaging has helped the patient cost-wise, time of acquisition and proper clinical diagnosis as cases which were missed in one modality were picked up in another.

CT has been an effective imaging tool in cases of suspected CVA which helps in identifying haemorrhage immediately due to its low acquisition time.CT is the best modality of choice in case ofcalcifications. But it has the limitations of radiation hazard and poor soft tissue contrast leading to poor identification of structural abnormalities.

Neurosonogram has been used in neonates and infants upto 1 year and has been an excellent tool in identifying various pathologies without the risk of radiation hazard as in CT or the longer acquisition time as in MRI.

MRIis the best modality of choice for all pathologies. MRI is an excellent neuroimaging tool which is highly effective in accurate diagnosis of the CNS pathologies. It is also useful in the treatment protocol and outcome prediction. It is used in follow up of cases as it can help restrict the overuse of antiepileptic agents. Hence MRI is the most recommended imaging modality in India in case of paediatric seizures. However the limitations of MRI is the high cost and long acquisition time which sometimes requires sedation or anaesthesia in uncooperative and sick children. It is also not readily available in all parts of India. Conventional methods like EEG are still used in the management in remote parts of the country.

Recommendations

All patients in the paediatric age group presenting with seizure must undergo neuroimaging study with other specific investigations as needed.

CNS infections especially tuberculosis is the most common neuroimaging finding in our study. Hence appropriate anti tuberculous strategies have to be followed with maintaining proper hygiene to prevent any infection.

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