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Original Article

Radiology Section

Study of Magnetic Resonance Imaging (MRI) of Brain in Children with Cerebral Palsy

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ABSTRACT

Introduction: One of the most common forms of severe disability of childhood is cerebral palsy which has a special relationship to preterm birth. Cerebral palsy is a broad term used to describe a spectrum of non-progressive motor disabilities, resulting from brain damage at or around birth. It presents with muscle spasticity with involuntary movements, impaired mobility, seizures etc. At present, cerebral palsy has no cure and it is managed symptomatically.

Aim: To study the different lesions in the brain in children with clinically diagnosed cerebral palsy and correlation of the findings on MRI brain with type of cerebral palsy.

Materials and Methods: Total 60 diagnosed cases of cerebral palsy were evaluated with history and clinical examination. Cerebral palsy children were investigated by performing neuroimaging (MRI). The MRI scans were conducted on a GE Sigma 1.5 Scanner. Routinely, the scans obtained were T1 Weighted, T2 Weighted and FLAIR (axial, coronal and sagittal) sequences. In each patient, the images were assessed for any abnormal signal in the brain parenchyma, myelination of brain as per age of the baby and size of the ventricle.

Results: The maximum number of children (36%) were from the age group 1-2 years followed by 30% in the age group of < 1 year and 18% in age group of 3-4 years. Out of 60 patients 61.66% were males and 38.33% females. The majority of patients were delivered pre-term (60%) followed by term delivery (40%). The majority of patients had spastic quadriplegia type of cerebral palsy. Periventricular leukomalacia was the most common abnormality found on imaging. The corpus callosum agenesis was seen in 1 (20%) patient.

Conclusion: The MRI scans help to reveal the pathologic causes leading to the condition with the MRI brain findings having a strong correlation with the clinical findings. The relationship between the locality of brain lesions, the structure and clinical functions in children with CP point to further workup as they are important pre-requisites for questioning reorganization and plasticity.

Keywords: Encephalopathy, Hypoxia, Preterm birth

INTRODUCTION

The term cerebral palsy is a broad term used to describe a spectrum of non-progressive motor disabilities, resulting from brain damage at or around birth. It is one of the most common forms of severe disability of childhood and has a special relationship to preterm birth. Prevalence of cerebral palsy is around 2 per 1000 live births with increase in prevalence in very low birth weight children and those born preterm to around 40 to 100 per 1000 live births [1,2]. Cerebral palsy presents with a wide variety of clinical symptoms which include difficulty in language, learning, epilepsy, hearing as well as vision impairment [3]. The basis of definition of cerebral palsy is usually phenomenological in origin, which implies that cause of cerebral palsy is related to any lesion within the brain, any interference and abnormality in brain development.

Cerebral palsy presents with muscle spasticity with involuntary movements, impaired mobility, seizures etc. The four major types of cerebral palsy are: spastic, ataxic, athetoid/dyskinetic and mixed. At present there is no cure for cerebral palsy and it is managed conservatively [4,5].

All cases of cerebral palsy especially of unknown origin should undergo neuroimaging as recommended by The American Academy of Neurology. The recommendation is still controversial as there is not enough supporting evidence to the adequacy of the same.

The timing and the nature of brain lesions can be well depicted on MRI. It is being increasingly used in the workup of children with cerebral palsy but it is still important to determine how much it can assist in pointing towards the etiology of cerebral palsy being an expensive procedure. Also a general anesthetic

may also be required in young children [6].

Many risk factors have now come into play with a better survival rate presently as compared to earlier birth cohorts. Now, more children born extremely preterm also survive. Despite the revolution, several neonatal morbidities are still seen in preterm children for example periventricular white-matter lesions and intraventricular haemorrhage that will lead to cerebral palsy. Children with brain malformation, perinatal asphyxia, and other severe conditions who would not have survived 10 years ago do so today because of improved neonatal intensive care [7].

The potential benefits of neuroimaging and currently used techniques help in improving the understanding of etiology of cerebral palsy. Understanding the etiology and pathogenesis of cerebral palsy is the main contribution of neuroimaging, which also helps us to rule in or out the conditions implicated for genetic counselling for example brain malformations [7].

Thus, this study was carried out to define the etiology of cerebral palsy in correlation with neuroimaging findings.

MATERIALS AND METHODS

It was a cross-sectional study undertaken to study MRI of brain in children with cerebral palsy over a 2 year period from July 2015 to July 2017. The study was conducted in the Department of Radiodiagnosis, JNMC, AVBRH, Wardha, Maharashtra, India. The study population was children from 1 month to 14 years of age with cerebral palsy. In the present study a total sample size of 60 children fulfilling the inclusion and exclusion criteria were included.

Sample size was calculated with the following assumptions. Based on the pilot study, the prevalence of cerebral palsy was taken as 3% [8]. Sample size was estimated at 5% level of significance using the following formula-

$n=4pq/d^2$

Where, n= Sample size; p= Prevalence; q= (1-p); d= absolute precision

p=3%=0.03

q= (1–p) =1–0.08=0.97

d= 0.05

So,

$n=[4(0.03)(0.97)]/(0.05)^2=46.56$

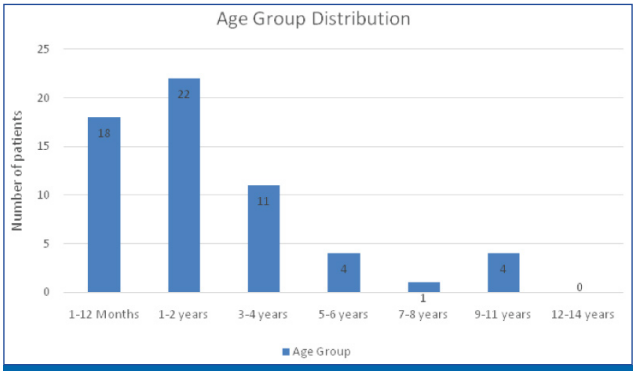
Children with clinical diagnosis of cerebral palsy, 1 month to 14 years of age were included in the study. Patients who were the critically ill and those who were not willing to undergo neuroimaging were excluded from the study. The study was approved by the Ethical Committee of the institute and taken permission from appropriate authority. Parents or guardians consent was taken before conducting the MRI brain study. The MRI scans were conducted on a GE Sigma 1.5 Scanner.

Routinely, the scans obtained were T1 Weighted, T2 Weighted and FLAIR (axial, coronal and sagittal) sequences. In each patient, the images were assessed for: Any abnormal signal in the brain parenchyma, myelination of brain as per age of the baby and size of the ventricle. Congenital anomalies were also looked for.

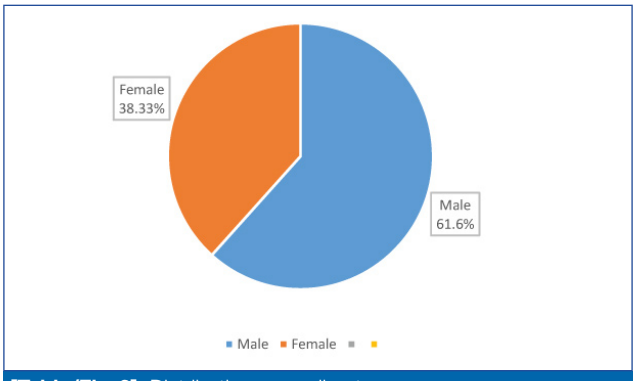
RESULTS

Out of the total sample size of 60 children the maximum number of children (n= 22, 36%) were from the age group 1-2 years followed by 30% in the age group of < 1 year (n=18) and 18% in age group of 3-4 years (n=11) [Table/Fig-1]. Males (n=37, 61.6%) were more common than females (n=23, 38.33%) [Table/Fig-2]. Majority of patients were delivered pre-term (n=36, 60%) followed by term delivery (n=24, 40%). Maximum patients were born with birth weight 2000-2500 grams (n=35, 58.33%). The patients with birth weight >2500 grams were 17 (28.33%) while with birth weight <2000 grams were 8 (13.33%). The distribution of patients according to clinical type of cerebral palsy [Table/Fig-3]. the majority of patients had spastic quadriplegia type of cerebral palsy. The unspecified form of cerebral palsy was seen in 14 (23.33%) while mixed form of cerebral palsy was observed in 12 (20%) patients.

Periventricular white matter abnormalities (n=28, 46.67%) [Table/Fig-4]. were the most frequent finding in my study [Table/Fig-5]. Followed by no abnormality detected on MRI



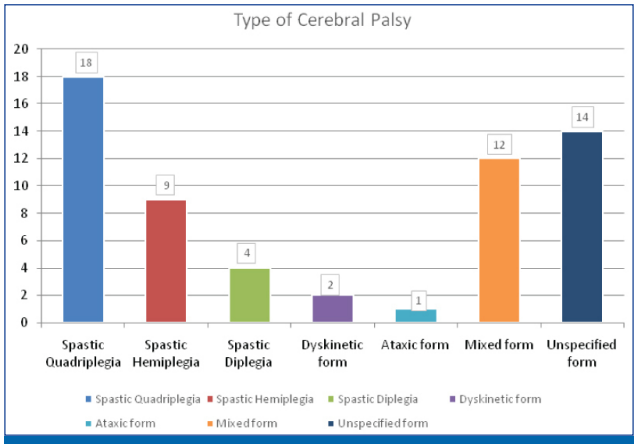
[Table/Fig-1]: Distribution according to age.



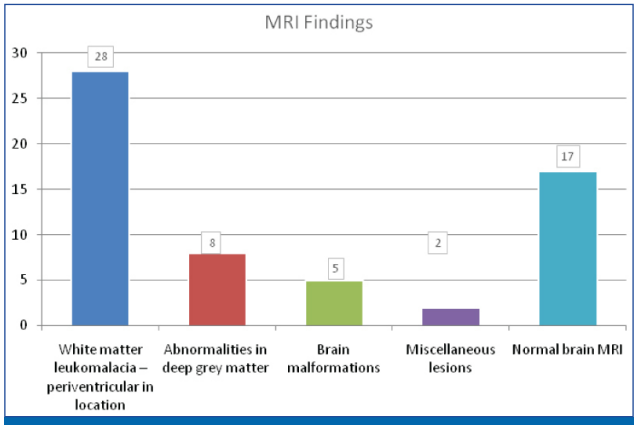
[Table/Fig-2]: Distribution according to sex.

brain which was seen in 17 patients (28.33%). Next on the list was deep grey matter abnormalities, noted among 8 (13.33%) patients. The malformations were seen in 5 (8.33%) patients while miscellaneous lesions were observed in 2 (3.33%) patients. The distribution of patients according to brain malformation in cerebral palsy [Table/Fig-6]. Showed out of total 5 patients with malformation, pachygyria was observed in 2 (40%) patients followed by lissencephaly (40%).The corpus callosum agenesis was seen in 1 (20%) patient.

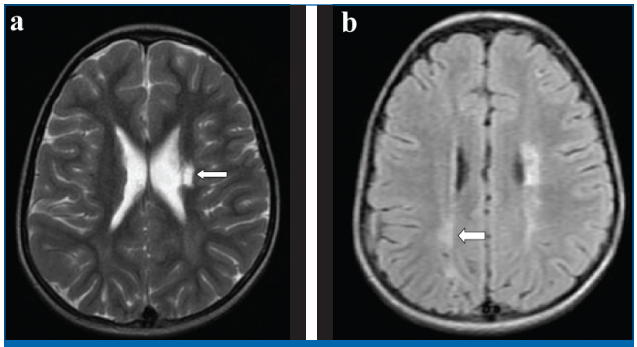
Changes in the corpus callosum was also separately studied [Table/Fig-7]. Where majority of children revealed mild diffuse thinning (n=7,11.67%) [Table/Fig-8] followed by thinned body of corpus callosum seen in 3 (5%) patients. The corpus callosum agenesis was seen in 1 (1.67%) patient [Table/Fig-9]. while 46 (76.67%) patients had normal MRI findings related to corpus callosum. The correlation of clinical type of cerebral



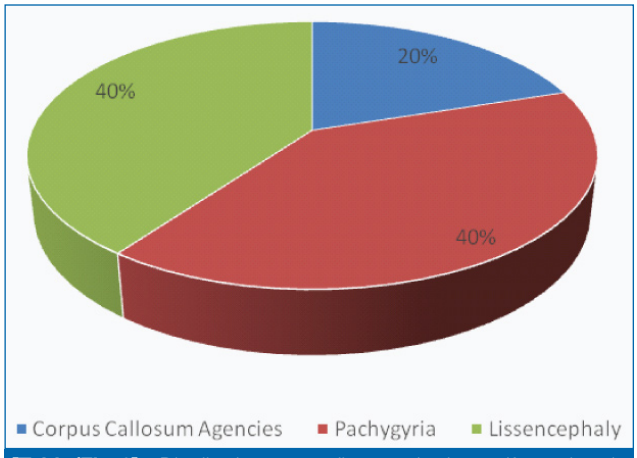
[Table/Fig-3]: Distribution according to clinical type of cerebral palsy.



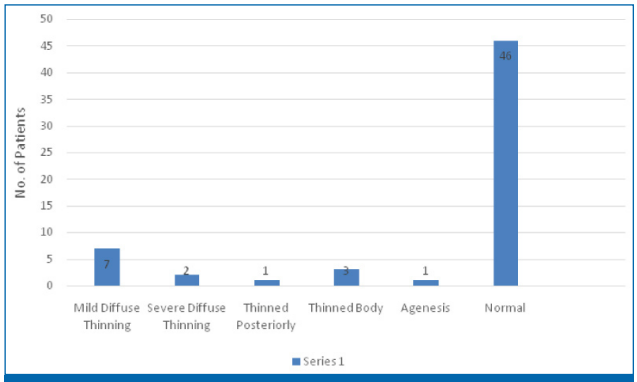
[Table/Fig-4]: Distribution according to spectrum of MRI findings.



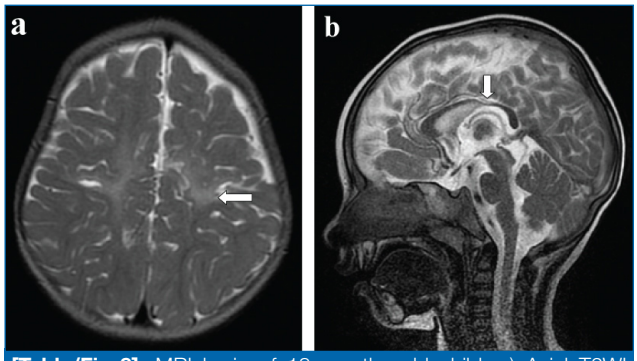
[Table/Fig-5]: MRI of 1.1 years old child- a) Axial T2WI image showing chronic infarct in left centrum semiovale (straight arrow) and; b) FLAIR MR image showing periventricular hyperintensities suggestive of periventricular leukomalacia (straight arrow).
*Both images appear hyperintense on T2WI and FLAIR.



[Table/Fig-6]: Distribution according to brain malformation in cerebral palsy.



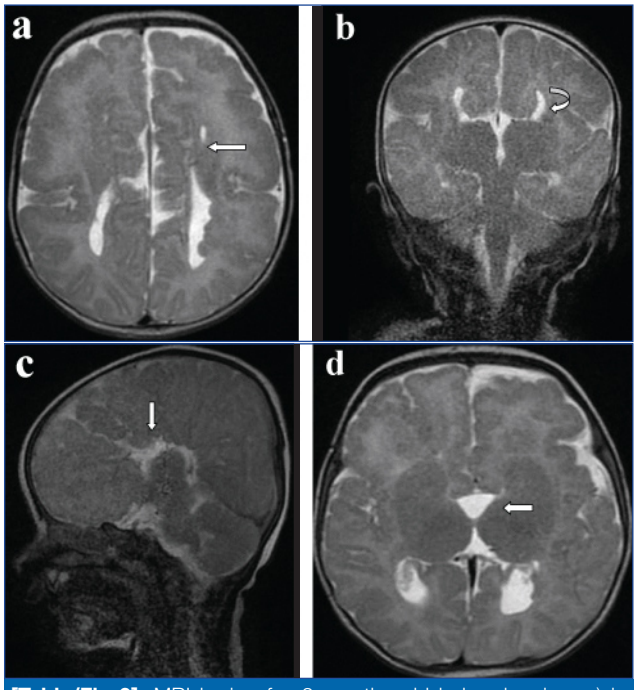
[Table/Fig-7]: Distribution according to corpus callosum MRI findings in cerebral palsy.



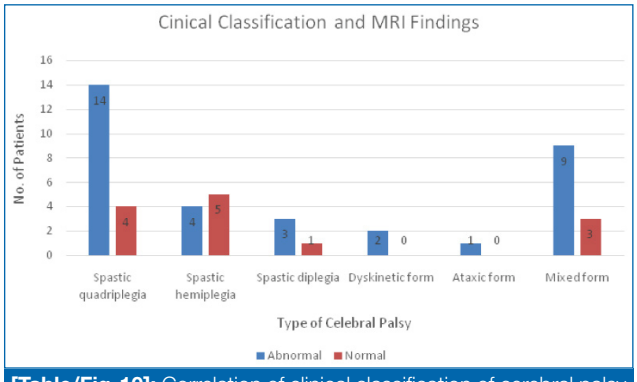
[Table/Fig-8]: MRI brain of 18 months old child: a) Axial T2WI showing supraventricular hyperintensities (straight arrow); b) Sagittal T2WI revealed diffuse thinning of corpus callosum (straight arrow).

palsy and MRI findings among patients is shown in [Table/Fig-10]. It was observed that out of 60 patients, 43 (71%) had abnormal MRI findings.

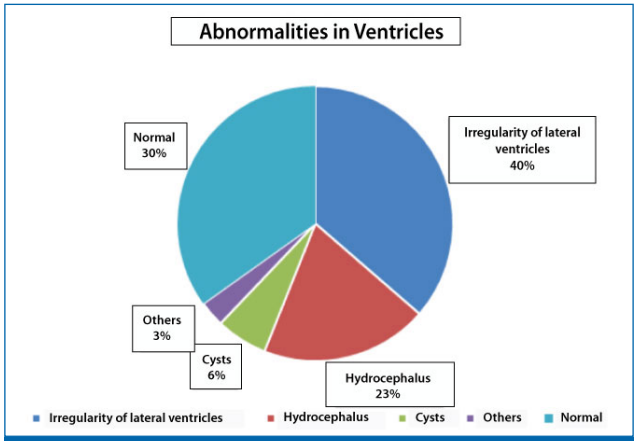
The distribution of patients according to abnormalities showed out of total 60 patients with developmental delay was observed in 56 (93.33%) patients followed by abnormal muscle tone (n=35, 58.33%). Seizures were seen 17 (28.33%) patients while mental retardation among 13 (21.67%) patients. Among 3 (5%) patients ophthalmic impairment was seen. Ventricular abnormalities were next studied. It was observed that out of 60 children, 23 (38.33%) had irregularity of lateral ventricles and 14 (23.33%) children showed hydrocephalus. four children had cysts within the ventricles [Table/Fig-11]. For example in [Table/Fig-12] MRI brain axial sections (T2WI) in a 9 month old preterm boy reveals severely dilated lateral and third ventricles with irregularity of the ventricular system and periventricular hyper intensities suggestive of periventricular leukomalacia. Another example in [Table/Fig-13]. In a six month old pre-term boy, very low both weight with history of birth asphyxia MRI brain study reveals communicating hydrocephalous. The distribution of patients according to leukodystrophies [Table/



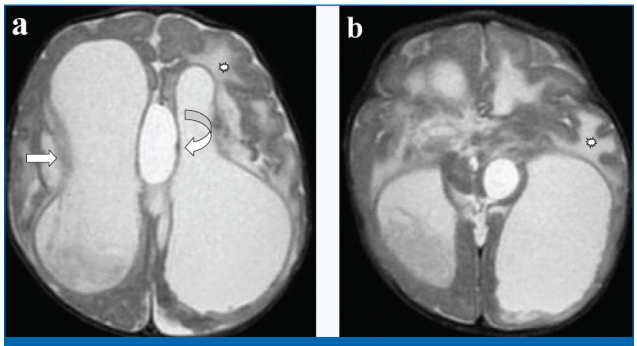
[Table/Fig-9]: MRI brain of a 2 months old baby showing: a) in axial T2W MR image, parallel configuration of the lateral ventricles (straight arrow); b) Coronal T2W MR image reveals the viking helmet appearance (curved arrow); c) Sagittal T2W MR image reveals completely absent corpus callosum, absent cingulate sulcus with the sulci of medial hemisphere seen reaching in a radial fashion (straight arrow) onto the third ventricle; d) Axial T2W MR image reveals a dilated high riding third ventricle (straight arrow).



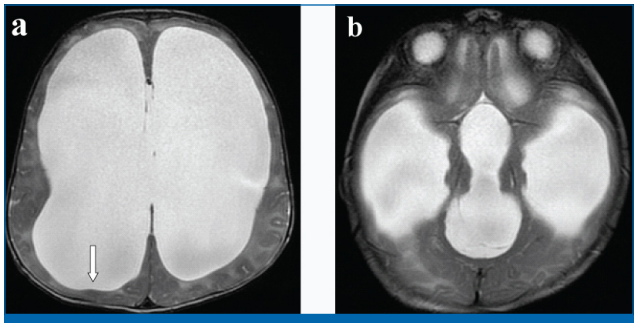
[Table/Fig-10]: Correlation of clinical classification of cerebral palsy and MRI findings.



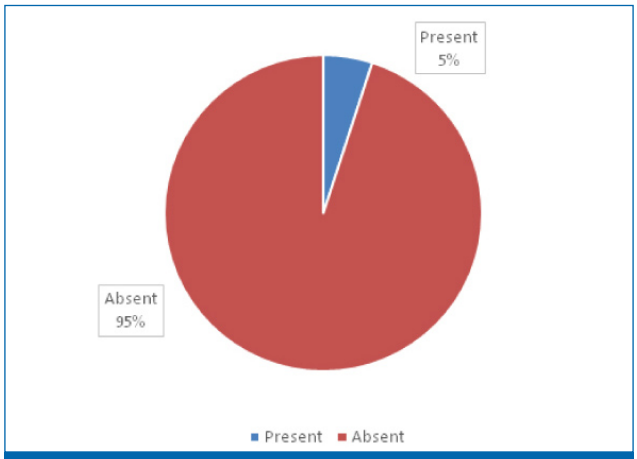
[Table/Fig-11]: Distribution according to abnormalities in ventricles.



[Table/Fig-12]: MRI brain axial sections (a,b) T2WI reveals severely dilated lateral (straight arrow) and third ventricles (curved arrow) with irregularity of the ventricular system and periventricular hyperintensities (star) suggestive of periventricular leukomalacia.



[Table/Fig-13]: MRI brain study in 6 month old pre-term boy, very low birth weight with history of birth asphyxia, axial sections (a,b) reveals communicating hydrocephalous with irregular walls of lateral ventricles (straight arrow in a).



[Table/Fig-14]: Distribution according to leukodystrophies among patients.

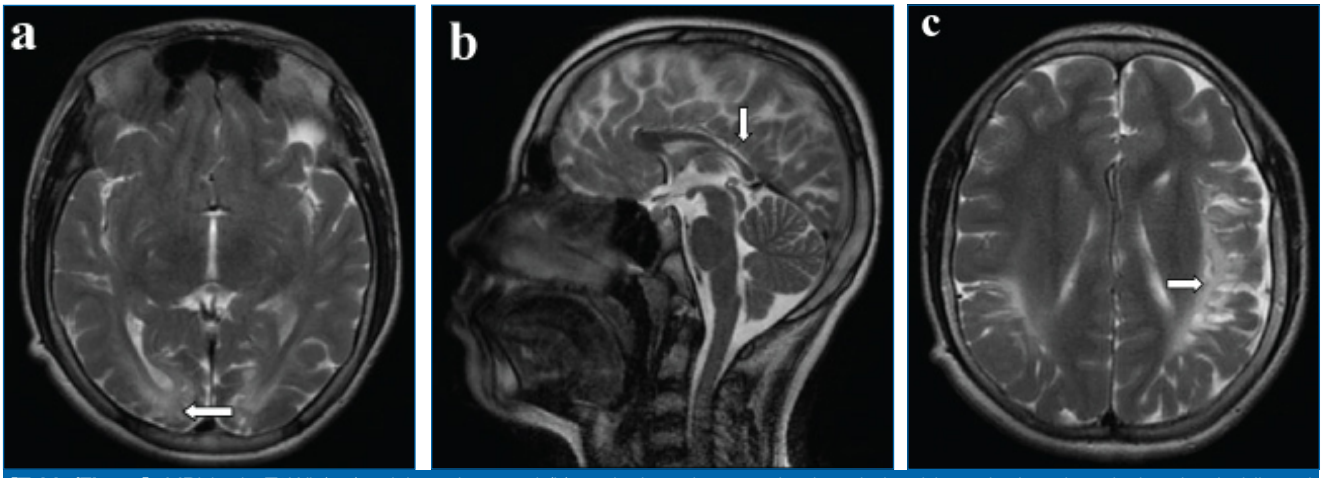
Fig-14]. showed out of total 60 patients leukodystrophies were observed in 03 (5%). Among all the patients one patient with Metachromatic Leukodystrophy (MLD), one case of Adrenoleukodystrophy (ALD) [Table/Fig-15] and one case of cystic leukodystrophy [Table/Fig-16] were discovered.

DISCUSSION

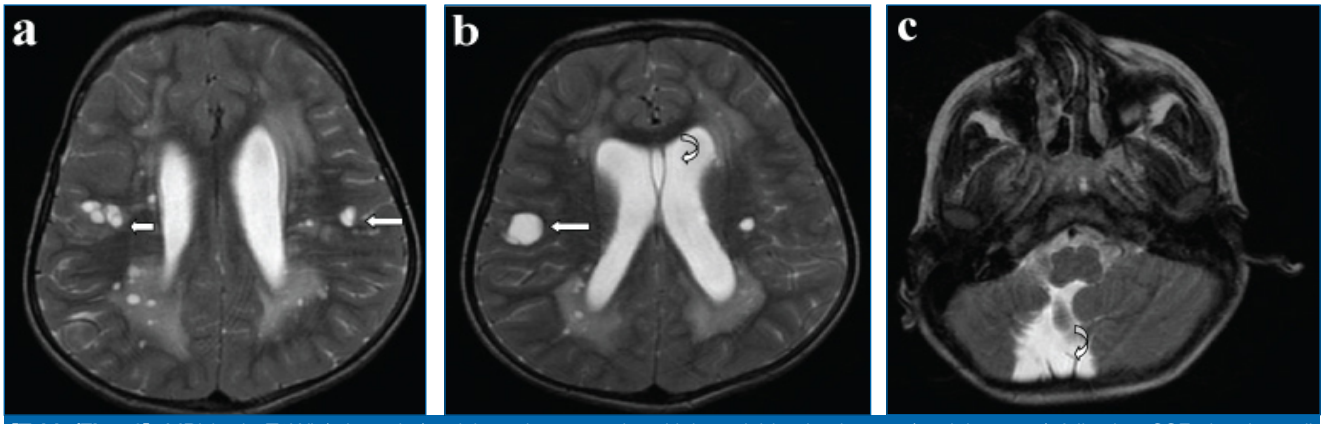
In present study, most of the children were in the age group ranging from 1 to 2 years, 22 in number followed by those less than 1 year of age, 18 in number.

A contrast was found to the study done by Moifo B et al., [9] to determine and describe common brain lesions of cerebral palsy patients observed that the mean age of the study population was 42 months with 77.4% aged 0 to 60 months.

In the present study the distribution of patients according to



[Table/Fig-15]: MRI brain T2WI (a,c) axial sections and (b) sagittal section reveals altered signal intensity in subcortical region in bilateral parietotemporal region (straight arrow) hyperintense on T2WI, suggestive of adrenoleucodystrophy. Mild signal intensities in peritrigonal region appearing hyperintense on T2WI can be seen with thinned out posterior body and splenium of corpus callosum (straight arrow) can also be appreciated on the sagittal MR image.



[Table/Fig-16]: MRI brain T2WI (a,b and c) axial sections reveal multiple variable sized cysts (straight arrow) following CSF signal on all sequences noted throughout the brain parenchyma in periventricular and subcortical region in bilateral parietal region which showed no restirction on DWI suggestive of cystic leukodystrophy. Additional findings of cavum septum pellucidum (curved arrow in b) seen as a CSF filled space between the leaflets of septum pellucidum and asymmetric mega cisterna magna (curved arrow in c) suggestive of focal cerebellar cortical dysplasia are also seen.

their sex and respective percentage showed that out of 60 patients 61.6% were males and 38.33% females. The findings were in accordance to study done by Moifo B et al., [10], Karumuna and Mgone [11] found a sex ratio of 1.3 in favour of males, while Ndiaye M et al., [12] found a sex ratio of 1.44 in favour of males.

The distribution of patients according to delivery by weeks of gestation showed that majority of patients were delivered pre-term (68.33%) followed by term delivery (31.67%). The incidence of cerebral palsy was more in children born prematurely than those born at term. The number of children born preterm in the study were also more in number.

The findings were in contrast to study done by Aggarwal A et al., [13] where out of 98 children diagnosed with cerebral palsy at a tertiary centre observed that only around 22.2% of children out of total 98 were premature.

In my study the distribution of patients according to birth weight showed that the majority of patients were with birth weight 2000-2500 grams (58.33%) The patients with birth weight >2500 grams were 17 (28.33%) while with birth weight <2000 grams were 8 (13.33%).

The distribution of patients according to clinical classification of cerebral palsy showed that the majority of patients had spastic quadriplegia. The unspecified form was seen in 14 (23.33%) while mixed form of cerebral palsy was observed in 12 (20%) patients.

Similar findings were seen in study done by Aggarwal A et al., [13] where the most frequent clinical type of cerebral palsy was spastic (75.83%), followed by hypotonic (1.67%), dystonic (1.67%) and the least common being the mixed (2.5%). Among spastic classification, most cases had involvement of upper and lower limb bilaterally.

The distribution of patients according to MRI findings among cerebral palsy patients showed that the majority of patients had periventricular white matter abnormalities (46.67%) followed by normal MRI brain seen in 17 patients (28.33%). Next frequent finding was deep grey matter abnormalities noted among 8 (13.33%) patients. The malformations were seen in 5 (8.33%) patients while miscellaneous lesions were observed in 2 (3.33%) patients. This is in contrast to a study done by Benini R et al., where he evaluated 213 patients out of which 126 (60%) had available MRI imaging results and were included in analysis [14]. Ninety children (71%) out of total 126 patients had abnormal MRI brain findings, which included 51 boys and 39 girls and 36 children (29%) had normal MRI brain which included 17 males and 19 females. In a study done by Aggarwal A et al., [13] in among 98 children with neuroimaging, around 94 (95.92%) children had abnormal findings. The various findings seen were periventricular white matter abnormalities (34%), deep gray matter abnormalities (47.8%), brain malformations (11.7%) and other various lesions (6.5%).

The distribution of patients according to brain malformation in cerebral palsy showed out of total 5 patients with malformation, pachygyria was observed in 2 (40%) patients belonged followed by lissencephaly (40%). The corpus callosum agenesis was seen in 1 (20%) patient.

In a study done by Aggarwal A et al., [13] the various brain malformations seen in children with cerebral palsy were focal cortical dysplasia and lissencephaly both seen in around 27% of patients, cranio vertebral anomalies, arachnoid cyst and pachygyria both seen in around 9% of patients and colpocephaly seen in around 18% patients.

The distribution of patients according to corpus callosum MRI findings among cerebral palsy patients showed that in majority of patients observed mild diffuse thinning (11.67%) followed by thinned body of corpus callosum in 3 (5%) patients. The corpus callosum agenesis was seen in 1 (1.67%) patient while 46 (76.67%) patients had normal MRI findings related to corpus callosum.

In the present study, it was observe that out of 60 patients, 23 (38.33%) had irregularity of lateral ventricles. It was also observed that 14 (23.33%) patients showed hydrocephalus and 4 patients had cyst in the ventricles.

Numerous cysts replaced the white matter in periventricular location due to deficiency of the same in periventricular region and also in centrum semiovale. The cyst integrity with the ventricle is lost with the destruction of the ependyma between the two. Ventricle appears irregular in shape with jagged edges and expansion locally or passively [15]. It presents as suffocation and is commonly observed in children born preterm or at term.

In the present study, ventricular abnormalities were irregular ventricular contour and ventricular enlargement, reflecting incorporation of parenchymal cysts or white matter hypoplasia, with ventricular enlargement alone. The ventricular trigones were slightly rounded. All had abnormal ventricles with irregular contour indicating the presence of periventricular cysts.

Similar findings were seen in study by Truwit CL et al., [16] where ventricular abnormalities were apparent in 20 patients born at term, including 12 (41%) with an irregular ventricular contour and ventricular enlargement, seven (24%) with ventricular enlargement alone and one with hydranencephaly.

It was seen that, out of total 60 patients, 14 (23.3%) showed hydrocephalus. Among 14 patients with hydrocephalus 07 (50%) patients had mild hydrocephalus, 05 (38.46%) had moderate hydrocephalus and 02 (15.38%) had severe hydrocephalus. Among all the patients with hydrocephalus, ten had communicating and three had non-communicating hydrocephalus.

In a study done by Rankin J et al., on congenital anomalies seen in children diagnosed with cerebral palsy observed that congenital hydrocephalus was present in 17.3% of cerebral palsy patients. Hydrocephalous was more commonly seen in children born at term than those born prematurely [17].

The distribution of patients according to leukodystrophies revealed that out of 60 patients leukodystrophies were observed in 03 (5%). Among patients two patients with MLD and one case of ALD was observed. Similar findings were observed in study done by Aggarwal A et al., leukodystrophies constituted only 7.5% [18].

Cystic leukodystrophy was present as multiple variable sized cysts following CSF signal on all sequences noted throughout the brain parenchyma in periventricular and subcortical region in bilateral parietal region [19].

LIMITATION

Limitations pressed upon by the size of the sample restrict out ability to judge the findings on MRI in the motor types less commonly seen.

Another limitation is that few children with normal MRI may have conditions genetic in origin. An example is hereditary spastic paraplegia, which might be the presenting symptom in children included in the study. Weakness and progressive spasticity is seen in these patients. When no family history is available or no previous MRI scans have been done, the diagnosis of hereditary spastic paraplegia is difficult.

Although, MRI can yield knowledge about the pathogenesis of motor disorder, the use of CP tag cannot be prevented by normal MRI. Mild cases may show normal MRI scans and further investigations may disclose a second diagnosis.

If the child is sedated there is also a risk of excessive sedation. Allergic reactions to contrast media though rare are still recognized in patients with poorly functioning kidneys. One such severe complication is nephrogenic systemic fibrosis.

Children are difficult to image because of their inability to lie still which may be due to various causes like severe pain and confusion. Child may also be anxious causing difficulty in scanning.

MRI is an expensive modality and it takes a longer time to perform MRI as compared to other modalities.

CONCLUSION

The pathological basis and clinical correlations of the findings with the type of CP is better understood with MRI scans. The timing and the nature of brain lesions can also be well depicted. The relationship between the locality of brain lesions, the structure and clinical functions in children with CP point to further workup as they are important prerequisites for questioning reorganization and plasticity.

These findings may be useful in helping parents, clinicians, and others involved in the care of children with CP to understand the nature of the children's condition and to predict their needs in the future.

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