ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 11(D), pp. 29692-29697, November, 2018

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

CHARACTERIZATION OF MAGNETIC RESONANCE IMAGING PATTERNS OF CEREBRAL PALSY AND THEIR ASSOCIATION WITH CLINICAL FINDINGSIN CHILDREN: AN HOSPITAL BASED OBSERVATIONAL STUDY

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DOI: http://dx.doi.org/10.24327/ijrsr.2018.0911.2909

ARTICLE INFO

Article History:

Received 13th August, 2018
Received in revised form 11th September, 2018
Accepted 8th October, 2018
Published online 28th November, 2018

Key Words:

Leukomalacia; Diplegia; Quadriplegia; Diplegia; Dyskinesia; MRI

ABSTRACT

This one year observational study was carried out in the Department of Radio-diagnosis, J.J.M. Medical College, Davangere. A total of 35 children with clinical diagnosis of cerebral palsy underwent MRI brain scan August 2016 to August 2017.All the patients of age group between 1-10 years, who are clinically diagnosed as cerebral palsy were included in the study.

The worldwide incidence of CP is approximately 2 to 2.5 per 1000 live births. The incidence is higher in males than in females 1.3:1. In India, exact incidence and prevalence from is not known. Prevalence of CP is in the range of 1.5 to 2.5 per 1000 live births.

In this study slight male preponderance was observed with 58.5% of the boys and boy to girl ratio of 1.40:1. The commonest age group was one to three years (30.5%) and the mean age 3.94 ± 3.06 years. MRI brain scan revealed 29.50% of the children with posterior involvement and commonest MRI findings was periventricular white matter (47%). The other common findings noted were porencephalic cysts (14%) and myelination (11.5%). Periventricular leukomalacia (38%) was the commonest diagnosis on MRI followed by cystic degeneration and basal ganglia (11.5% each). The MRI diagnosis correlated well with clinical diagnosis (80.5%) and higher correlation was noted with spastic triplegia (100%).

INTRODUCTION

Cerebral palsy (CP) was first described in 1862 by an orthopedic surgeon named William James Little. It is a motor disorder which results in a non-progressive insult to the developing brain resulting in wide variety of clinical presentations related to cortical or sub-cortical cerebral insults during the first year of life.[1,2]

The worldwide incidence of CP is approximately 2 to 2.5 per 1000 live births. The incidence is higher in males than in females 1.3:1. In India, exact incidence and prevalence from is not known.[3] However, it is estimated that CP is present in 3 per 1000 live births but it is postulated that, the expected actual figure may be much higher in a developing country.[4] The incidence of CP is strongly associated with gestational age, occurring in 1 of 20 surviving preterm infants. Although, prematurity is the commonest risk factor for causing CP, the majority of affected children are full-term.

Historically, CP was thought to be associated with birth trauma. However at present times congenital, genetic, inflammatory, anoxic, traumatic, toxic, and metabolic conditions have been implicated as causes of CP. Prenatal risk factors include intrauterine infections; chorioamnionitis; exposure to teratogens; placental complications; and maternal conditions, such as mental retardation, history of seizures, and hyperthyroidism. New model look into inflammatory-mediated models of CP and developmental sequelae are being developed. Perinatal events such as preterm birth, low birth weight, intracranial hemorrhage, infection, seizure, hypoglycemia, and hyperbilirubinemia are well-known risks for neurologicalsequelae.[5]

The parents and pediatricians concerns about abnormal motor development provide the first clue to a possible diagnosis of CP and may initiate referral to a higher physician such as pediatric neurologist. The history may reveal risk factors; findings from the physical examination may identify the type of CP.[6]The traditional diagnostic approach consists of early assessment of impairments in muscle tone, strength, and control; assessment of involuntary movements; asymmetry; persistence of primitive reflexes; and late development of postural responses. CP also can be detected based on functional limitations. Estimating

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functional limitations using the motor quotient (motor age divided by chronological age times 100) is also a diagnostic tool.[7-9] With the development of CT, radiographic correlation with clinical data regarding prenatal, perinatal, and postnatal asphyxia became possible, particularly with respect to morphologic changes of the cerebral white matter.[10] The sensitivity of CT, however, is limited in many cases of cerebral palsy. In particular, while state-of-the-art CT is sensitive to severe anomalies of brain development, such as schizencephaly, MR is more sensitive than CT in the detection of both subtle brain malformations, such as callosalhypogenesis, polymicrogyria, and milddegrees of white matter damage.[10] Hence MRI is preferred to CT because it is more likely to identify a cause.[11,12]

Though CP has been the subject of numerous clinical and neuroradiologic studies to assess the relationship of pre-, peri-, and postnatal events to CP,[13-15] clinical studies have been limited by the availability of historical information regarding prenatal care and possible prenatal insults. Neuroradiologic studies have been limited in their usefulness, primarily because of the limited capabilities of neuroimaging in the era before computed tomography (CT) and magnetic resonance (MR) imaging. Hence the present study was undertaken to characterize the magnetic resonance imaging patterns in children with cerebral palsy and find their association with clinical findings.

Aims and Objectives

- To study the patterns of magnetic resonance imaging in children with cerebral palsy.
- To determine the various types of morphological abnormalities seen on MRI in patients with cerebral palsy and its association with clinical findings in a set population.

METHODS

Source of Data

All the patients of age group between 1-10 years, who are clinically diagnosed as cerebral palsy and admitted in hospitals attached to JJM Medical college, Davanagere.

Study Period: 1 years.

Sampling Method: Simple random sampling.

Inclusion Criteria

All the patients of age group between 1-10 years, who are clinically diagnosed as cerebral palsy, will be undergoing neuroimaging (MRI brain) and the scans were reviewed in the department of radio-diagnosis in Bapuji Hospital and Chigateri General Hospital, Davangere.

Exclusion Criteria

Those with regression of milestones.

- Neuroimaging suggestive of metabolic disorders.
- Children's with inflammatory brain diseases such as meningitis, encephalitis and intracranial space occupying lesions(i.e. brain abscess, tuberculoma, neurocycsticercosis and neoplastic lesions of cerebral cortex)
- All patients were also subjected to metabolic screen(blood and urine) to exclude associated metabolic disorder

Children fitting in these criteria will be taken up for the study and the relevant data will be collected.

T1 weighted, T2 weighted and FLAIR images will be obtained by a PHILIPS ACHIEVA 1.5 TESLA MAGNETIC SYSTEM.

Standardized clinical examination results, parental questionnaire responses, MRI results, and obstetric, genetic, and metabolic data from medical records will be accessed for the study.

Technique

Imaging is done with 1.5 Tesla Philips Achieva machine using Sense Head Coils. The following sequences will be selected as required.

1. T2-axial
2. FLAIR-axial
3. T2-coronal
4. T1-sagittal
5. T2-FFE-Axial
6. DWI-Axial

The study is mainly based on investigations as radiology itself is a tool of investigation. The study involves only humans. Informed consent would be taken after explaining about and before any procedure.

Statistical Analysis

Data will be analyzed using descriptive statistics and chi-square test. Suitable statistical software will be utilized for analysis.

Study Variables

The MRI images were analyzed by the Consultant Radiologist for MRI findings as below.

- Type of cerebral palsy
- Nature of cerebral palsy
- Clinical diagnosis
- MRI predominance
- MRI diagnosis
- Correlation of MRI diagnosis with clinical diagnosis

RESULTS

The present one year observational study was done under the Department of Radio-diagnosis, J.J.M. Medical College, Davangere from August 2016 to August 2017.A total of 35 children attending with clinical diagnosis of cerebral palsy and referred for MRI brain scan at J.J.M. Medical College, Davangere were studied. The data obtained was analysed and the final results and observation were tabulated as below:

In the present study 57.1% of the children were males and 42.8% were females. The boy to girl ratio was 1.40:1.

In this study the commonest age group was one to three years (30.5%) followed by 4 to 6 years (29%). The mean age was 3.94 ± 3.06 years.

Of the perinatal risk factors associated, majority of the children are between 2.5 to 3.49 kg (51 percent) followed by children between 1.5 to 2.49 kg. Children of first order were found to constitute higher number of cases (57 percent).Neonatal resuscitation at birth and history of NICU admission were also cited as a risk factor for cerebral palsy at an older age.

Of the other co existant risk factors associated, jaundice was seen in the highest number of cases followed by feeding difficulties, seizures, respiratory distress and sepsis in the decreasing order of frequency.

Table 1 Distribution of children according to the birth history

Birth history	Findings	Number	Percentage
Gestation	1.50 to 2.49	15	43
	2.50 to 3.49	18	51
	3.5 or more	2	6
	Total	35	100
Birth order	First	20	57
	Second	10	29
	Third	4	11
	Fourth	1	3
	Total	35	100
Cry at birth	Immediate	20	57
	Delayed	11	31
	Weak	3	9
	Total	35	100
Resuscitation	Yes	26	74
	No	9	26
	Total	35	100
NICU admission	Yes	22	63
	No	13	37
	Total	35	100
Co-exiting conditions	Jaundice	7	35
	Feeding problems	6	30
	Seizures	4	20
	RDS	2	10
	Septicemia	1	5
	Cyanosis	0	0
	Total	20	100

In the present study most of the children had quadriplegia (26.5%) followed by diplegia (25%), dyskinesia (19.5%), hemiplegia (13.5%), triplegia (0.5%).

Table 2 Distribution of children according to the type of cerebral palsy

Type	Number	Percentage
Quadriplegia	9	26
Diplegia	9	26
Dyskinesia	7	20
Hemiplegia	5	14
Triplegia	1	3

In this study spastic cerebral palsy was noted in 63% of the patients while dystonic, choreoathetoid and ataxia was present among 14%, 11% and 6% respectively.

Table 3 Distribution of children according to the nature of cerebral palsy

Nature	Number	Percentage
Spastic	22	63
Dystonic	5	14
Choreoathetoid	4	11
Ataxia	2	6

In the present study MRI brain scan revealed 29.50% of the children with posterior involvement and 16.50% of the children with anterior and middle area.

Table 4 Distribution of children according to the MRI predominance

Predominance	Number	Percentage
Posterior	10	29
Anterior and middle	6	17
Middle and posterior	5	14
Middle	3	8
Anterior middle and posterior	2	6
Anterior	1	3
Normal	8	23
Total	35	100

In this study the commonest MRI findings was periventricular white matter (47%) followed by cerebral cortex (34.5%).

Table 5 Distribution of children according to MRI findings

MRI Findings	Number	Percentage
Periventricular white matter	16	45.7
Cerebral cortex	12	34.3
Corpus callosum	8	22.9
Thalamus	5	14.3
Globus pallidus	4	11.4
Cerebral cortex	3	8.57
Putamen	3	8.57
Caudate nucleus	2	5.7
Internal capsule	2	5.7
Cerebellar white matter	1	2.86

In the present study the other common MRI findings included porencephalic cysts (25%) followed by myelination (20%)

Table 6 Distribution of children according to the other MRI findings

MRI findings	Number	Percentage
Porencephalic cysts	5	25
Myelination	4	20
Ventricular enlargement	3	15
Cerebellar atrophy	3	15
Focal infarct	2	10
Malformation	2	10
Enlargement of PCSA space	1	5

In this study the commonest clinical diagnosis was spastic diplegia (24.5%) followed by spastic quadriplegia (23%).

Table 7 Distribution of children according to the clinical diagnosis

Diagnosis	Number	Percentage
Spastic diplegia	8	22.85
Spastic quadriplegia	7	20
Dystonic	5	14.28
Spastic hemiplegia	4	11.43
Choreoathetoid	4	11.43
Dyskinetic	3	8.57
Mixed	1	2.86
Ataxic	1	2.86

Hypotonic	1	2.86
Spastic triplegia	1	2.86
Total	35	100

In the present study the commonest MRI finding was noted as periventricular leukomalacia (38%). The next common diagnosis was cystic degeneration (19%) followed by basal ganglia (11.5%).

Table 8 Distribution of children according to the MRI diagnosis

Diagnosis	Number	Percentage
Periventricular leukomalacia	13	37.15
Cystic degeneration	7	20.0
Basal ganglia	4	11.4
Atrophy	2	5.7
Infarct	2	5.7
Focal gliosis	2	5.7
Malformation	1	2.9
Demyelination	1	2.9
Normal	3	8.6
Total	35	100

In this study in among the children with periventricular leukomalacia, most of the children the predominant area was posterior (42.11%). The predominance of anterior and middle, and middle and posterior was noted in 23.68% of the children each.

Table 9 Distribution of children according to the white matter predominance in patients with periventricular leukomalacia

Predominance	Number	Percentage
Posterior	5	38.5
Anterior and middle	3	23
Middle and posterior	2	15.4
Middle	1	7.7
Anterior	1	7.7
Anterior middle and posterior	1	7.7
Total	13	100

In the present study among the children with clinical diagnosis of spastic diplegia, MRI findings revealed 62.5% of the children with periventricular leukomalacia while cystic degeneration was the commonest MRI finding in children with clinical diagnosis of spastic quadriplegia (63.04%), cystic degeneration and periventricular leukomalacia (6.4%) respectively.

In the present study among the children with clinical diagnosis of choreoathetoid cerebral palsy, 40% of the children had basal ganglia on MRI. The commonest MRI finding in children with clinical diagnosis of spastic hemiplegia was periventricular leukomalacia (38%), infarct and cystic degeneration (30%) each.

Basal ganglia (28.57%) and periventricular leukomalacia (21.43%) were the commonest MRI finding in children diagnosed to have dystonic cerebral palsy clinically.

In children with diagnosis of dyskinetic cerebral palsy, 23.53% of the children each had basal ganglia and focal gliosis on MRI and 66.67% of the children with clinical diagnosis ataxic cerebral palsy had atrophy on MRI.

DISCUSSION

The present one year observational study was undertaken in the Department of Radio-diagnosis, J.J.M. Medical College, Davangere. A total of 35 children with clinical diagnosis of cerebral palsy and referred for MRI brain scan from August 2016 to August 2018 were studied.

In the present study slight male preponderance was noted as 58.5% of the children were males and 41.5% were females and the boy to girl ratio was 1.40:1. These findings were consistent with a study by Najar BA *et al*.[16] from Srinagar, where 64.91% of the children were males and 35.09% were females and a study by Kulak W. *et al*.[17] who reported 67.27% of males. In European cerebral palsy study,[18] 61.9% of the children were males. In contrast to our findings Yamada K *et al*.[19] noted female preponderance with 60.52% of the children being females out of 38 cases.

The present study included children aged upto 10 years. The commonest age group was one to three years which was comprised on less than one third of the study population (30.5%) and the second commonest group was aged between 4 to 6 years (29%) and the mean age was noted as 3.94 ± 3.06 years. In European Cerebral Palsy study[18] the age at the time of examination ranged from 12 to 91 months, with a mean age of 46 months which was similar to the present study. In contrast, a recent study by Dobhal M. *et al*.[20] in Delhi reported the mean age as 61.0 (Range 56.5 -65.5) months. In another study by Najar BA *et al*.[16] from Srinagar, India, the commonest age group involved was 2-5 years which accounted for 78.94% and the least involved group was 11-16 years (3.50%). The differences observed in the age distribution of pattern of the present study and the other Indian studies[93,96] can be explained by the varying sample size of the study population and inclusion of difference age groups in latter studies.

In the present study maternal history revealed 37% of the preterm babies. History of consanguineous marriage among parents was present in 24.5% of the babies. Lack of antenatal care was reported by 4.5% of the mothers and home based delivery reported by 3% of the mothers. The mode of delivery was LSCS in 20.5% while instrumental in 3% of the babies. Also maternal complications of UTI, GDM, multiple gestation, PROM and PV bleeding were reported by 14.5%, 7%, 5%, 1% and 0.5% respectively. With regard to birth history, 43.5% of the babies had low birth weight (<2.50 Kgs) while delay and weak cry were noted in 32.5% and 9% of the babies. The resuscitation was done in 27% of the babies and history of NICU admission was noted 62% of the children with jaundice, feeding problems and seizures being the predominant causes (19.5%, 16.5% and 12.0% respectively.

In this study, most of the children had quadriplegia (26.5%) followed by diplegia (25%), dyskinesia (19.5%), hemiplegia (13.5%) and triplegia (0.5%). With regard to nature of cerebral palsy, spastic cerebral palsy was noted in nearly two thirds of the children (64%) and in the remaining, dystonic (13%), choreoathetoid (10%) and ataxia (5.5%) were present. Based on these evaluations maternal history, birth history, type and nature of cerebral palsy the commonest clinical diagnosis was spastic diplegia (24.5%) and spastic quadriplegia (23%). The other diagnosis noted were spastic hemiplegia (12%), dystonic

(14%), choreoathetoid (10.5%), dyskinetic (8.5%), mixed, ataxic (3% each), hypotonic (1%) and spastic triplegia (0.50%). In a study[16] from Srinagar, India, most common type of CP observed was spastic diplegia contributing to 49.10% of all cases. In contrast, European cerebral palsystudy[18] reported maximum children with diplegia (34.4%) followed by hemiplegia (26.2%), spastic quadriplegia (18.6%) and dyskinesia (14.4%).

In the present study among 29.50% of the children on MRI brain scan showed posterior involvement and 16.5% of the children with anterior and middle area involvement were present. The commonest MRI finding was periventricular white matter (47%) followed by cerebral cortex (34.5%), corpus callosum (22.5%), thalamus (14%) and globuspallidus (10.5%). The other common findings noted were porencephalic cysts (14%), demyelination (11.5%), ventricular enlargement and cerebellar atrophy (11% each). Based on these findings the commonest MRI diagnosis was periventricular leukomalacia (38%), cystic degeneration (19%), basal ganglia (11.5%), atrophy (5.50%), infarct (5%), focal gliosis (4.5%), malformation (4%), demyelination (1.5%). Among the children with periventricular leukomalacia, most of the children the predominant area was posterior white matter (42.11%).These MRI diagnosis observed in the present study was consistent with several other studies.

The European Cerebral Palsy study[18] showed that white matter damage of immaturity (WMDI, including PVL) was the most common finding (42.5%), followed by basal ganglia lesions (12.8%), cortical/subcortical lesions (9.4%), malformations (9.1%), focal infarcts (7.4%), and miscellaneous lesions (7.1%).

A population-based studies of brain imaging patterns in cerebral palsy also reported white matter injury as the most common imaging pattern for all children with CP, occurring in 19 to 45% of cases across three studies.[21]Krageloh-Mann and Horber[22] reported WMI in 56% of scans, but the results are not directly comparable since their review only included spastic–dyskinetic CP, and preterm children were over-represented in their review and under-represented in our review (52% vs 37% of the total cohort). On account of increased susceptibility to WMI, it was not unexpected that 31 to 71% of children born preterm would have this pattern, but perhaps it is more surprising that the imaging of 12 to 32% of children born at term also showed WMI.[21]

In the present study MRI findings correlated well with clinical diagnosis of patients with spastic triplegia (100%), spastic diplegia (100%), choreoathetoid (95.24%) and spastic quadriplegia (91.3%). The least correlation was noted with dyskinetic (47.06%), mixed (50%), and hypotonic (50%). The overall correlation of MRI findings with clinical diagnosis was found to be 80.5%. These findings suggest that, MRI with higher correlation with clinical diagnosis is a valuable tool and helps to determine the etiology and make better prognosis of CP. Kułak W, *et al*.[17] in 2008 also reported that, MRI in children with CP may help determine the etiology and make better prognosis of CP.

Overall the present study showed usefulness of MRI in the diagnosis of CP. Further studies in the coming years may focus etiological aspects and create awareness of possible preventive measures which will help in reducing the huge burden of the cerebral palsy.

CONCLUSION

Periventricular leukomalacia was most common diagnosis followed by cystic degeneration and basal ganglia. However, few patients were diagnosed with atrophy, infarct, focal gliosis, malformation and demyelination. Furthermore, MRI findings correlated well with clinical diagnosis. MRI findings highly correlated with spastic triplegia, spastic diplegia, choreoathetoid and spastic quadriplegia. Overall, MRI is a useful diagnostic modality which helps to detect abnormalities in patients with cerebral palsy which helps in understanding the causal pathways in CP which identify opportunities for future preventative strategies.

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How to cite this article:

Pranav Srinath Reddy *et al*., 2018, Characterization of Magnetic Resonance Imaging Patterns of Cerebral Palsy And Their Association with Clinical Findingsin Children: An Hospital Based Observational Study. *Int J Recent Sci Res.* 9(11), pp. 29692-29697. DOI: http://dx.doi.org/10.24327/ijrsr.2018.0911.2909

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