

## EVALUATION OF NEUROIMAGING IN CEREBRAL PALSY

**S.H. Hasanpour avanji MD**

Assistant Professor of Child  
Neurology, Iran University of  
Medical Sciences

Corresponding Author:  
S.H. Hasanpour avanji MD  
Ali Asghar Children Hospital  
Tel: +98 21 22226127

### **Abstract**

#### **Objective**

Cerebral palsy (CP), a common static motor neurological disorder of childhood with wide spectrum of underlying etiologies, can be demonstrated with different neuro imaging techniques. We undertook this study to investigate the diagnosis of intracranial lesions in children with CP and its correlation between clinical deficits and neuroradiological findings.

#### **Materials and methods**

In this prospective hospital-based study, the data of 120 patients with CP, aged below 18 years, referring to the neurology clinic of the Ali Asghar Pediatric hospital in Tehran was studied; data on their cranial neuroimaging findings was analyzed any possible association(s) between the gestational ages, prenatal history and neurological deficits were investigated.

#### **Results**

Of the 120 patients, 72 (60%) were male; 75% were aged below 7 years. Common predisposing factors were prenatal asphyxia, LBW, prematurity and toxemia of pregnancy. Of the 120 cases, 90%(107) had spastic CP, with the quadriplegic type being the most common (54%), followed by spastic paraplegia (21%); twenty-four patients (20%) had significant Periventricular Leucomalacia (PVL), a finding more common among those born pre-term. Sixteen patients had hemiplegic CP, 14 of whom showed unilateral lesions on brain MRI imaging. Ten (8%) had extra pyramidal CP, a condition more common among term born infants, while six of the 10(72%) showed significant abnormalities on the basal ganglia. Cerebral atrophy was seen in 60 (50%) of patients and PVL in 20%; encephalomalacia, gliosis, middle cerebral artery infarcts, PVL and gliosis indicated hypoxia as a risk factor for CP. Extent of MRI lesions correlated with the severity of neurological deficits in CP lesions, which were more extensive in Quadriplegics and double hemiplegics rather than paraplegics, and among those delivered preterm as compared to those born at term.

#### **Conclusion**

Radiological findings were found to be closely related to the type of CP and the neurological deficits and gestational ages of patients with brain insult; we believe that MRI is helpful in delineating the underlying etiology, extent, severity and timing of insult to the developing brain and prognostication in CP patients.

**Keywords:** Cerebral Palsy (CP), Magnetic resonance imaging (MRI) Neuroimaging, Spasticity

## Introduction

Cerebral palsy (CP), a common static motor neurological disorder of childhood with a wide spectrum of underlying etiologies, can be demonstrated with different neuroimaging techniques; research on the origins of CP remains a high priority(1), since advances in neuroimaging are play a significant role in the understanding of its underlying pathology (2). Neuroimaging, especially magnetic resonance imaging (MRI) provides detailed information about the related brain lesions (3). The aim of this study was to gain a deeper insight into the diagnosis of intracranial lesion in children with CP and analyze the relationship between imaging findings and types of CP.

## Materials & Methods

For this prospective hospital based study, 120 patients, aged below 18 years, referring to the pediatric neurology clinic of the Ali Asghar pediatric hospital in Tehran, between 1994 and 2005, and diagnosed with CP, were enrolled and investigated; cerebral palsy, defined as a persistent disorder of movement and posture caused by non-progressive damage to the developing brain (1), was classified into spastic CP (Quadriplegic, hemiplegic, diploidic, paraplegic and extra pyramidal, hypotonic and the mixed type, based on clinical presentation. Spastic cp was defined as a persistent disorder of movement and posture, with predominant spastic features, caused by non-progressive damage to the developing brain (2,4), and was classified as: 1-Hemiplegic, i.e. spasticity of the arm and leg on one side. 2-Paraplegic, spasticity of the lower extremities with a variable but lesser involvement of the upper limbs, and 3-Quadriplegic or spasticity of all four limbs, with involvement of the arm being more marked than or equal to that of the lower limbs (2). All patients underwent clinical and neurological examinations, followed by neuroimaging (MRI).

MRI was performed in all patients by a radio imaging specialist, using T<sub>1</sub> and T<sub>2</sub> weighted axial images. 90 patients of 210 patients who did not have brain imaging were excluded.

Imaging findings were divided to Brain atrophy, prefrontal Leucomalacia (PVL), encephalomalacia, corpus callosum deformity, Basal ganglia lesions (BGL) and neuronal migrational defects (NMD) in this study.

On the basis of etiology, MRI findings were categorized into four groups:

- 1: Destructive brain injury
- 2: Congenital brain anomaly
- 3: Postnatal brain injury
- 4: Unclassified (5)

Destructive injury was divided in to two sub groups:

Preterm and term brain injury; the former included prefrontal leucomalacia and post hemorrhagic porencephaly (4-5), whereas postnatal injury included, sequel of meningitis, encephalitis, encephalopathy and any trauma that occurred in the postnatal period, i.e. between the 28<sup>th</sup> day and up to 2 years (6). Unclassified injury included middle cerebral artery infarct, cerebral atrophy and hemi-baring atrophy(7, 8).

Differences between groups were assessed by chi-square test. All P values were two – tailed. Statistical significance was defined as P <0/005.

## Results

Of study patients, 72 patients (60%) were male; Over 75% fell into the under 7 year-old group; most of these, 45 (37,5%) were aged under 2 years.

Regarding gestational age, 55(46%) were preterm, while 60 (50%) were term and 5 (4%) were post term.(5) Diplopic CP was the most common type of palsy in preterm, while Quadriplegic was the most frequent type in term patients (table1).

The common predisposing factors were prenatal asphyxia, LBW, prematurity and toxemia of pregnancy. Spastic CP comprised 90% (107 of 120) cases, with the Quadriplegic type being the most common (54%), followed by spastic diplegia (21%) and hemipelagia 15%. There were 8 and 2% of the extra-pyramidal and mixed types respectively (table 2).

In this study, 91% of patients had abnormal MRI findings; lesions identified with MRI imaging were brain atrophy observed in 50%(figure-1); PVL in 20%(figure 2); encephalomalacia ( corpus callosum deformity) in 10% (figure 3). In 6 and 5% of patients, basal ganglia lesions and NMD respectively were observed (figure 4). In the remaining 9% neuroimaging studies revealed normal results (table 2). The relationship between radiological abnormality and gestational age is depicted in (table 3).

Following imaging, a few patients showed multiple

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lesions, the same form of atrophy found in most patients with other abnormalities.

Table 1: Correlation between gestational age and cerebral palsy typing in 120 patients with CP

Type of CP \ Gestational Age	Quadriplegic		Hemiplegic		Diplegic		Extra pyramidal		Mixed		Total	
	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)
Preterm	20	16.5	6	4	22	18	6	5	1	1	55	46
Term	43	36	8	6.5	4	3	3	2.5	2	1.5	60	50
Post term	2	1.5	3	2.5	-	-	1	1	-	-	5	4
Total	65	54	16	13	26	21	10	8.5	3	2.5	120	100

Table 2: Correlation between CP typing and MRI findings in 120 CP patients

Cp typing \ MRI finding	Brain Atrophy		PVL		encephalomalacia corpus callosum deformity		BGL		NMD		normal		total	
	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)
Quadriplegic	50	42	5	4	3	2	-	-	4	4	3	2	65	54
Hemiplegic	2	1.5	4	3	8	7	-	-	1	1	1	1	16	15
Diplegic	6	5	14	12	1	1	1	1	1	1	3	2	26	21
Extra pyramidal	1	1	1	1	-	-	5	4	1	1	3	2	10	8
Mixed type	2	1.5	-	-	-	-	-	-	-	-	1	1	3	2
Total	60	50	24	20	12	10	6	5	7	6	11	9	120	100

PVL: Preventricular Leucomalacia

MRI: Magnetic resonance Imaging

BG: Basal ganglia

NMP: Neuronal migrational defects

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Table 3: Correlation between gestational age and abnormal radio imaging findings in 120 patients with cerebral palsy.

Radio imaging finding Gestational Age	Brain atrophy		PVL		Encephalon malacia and corpus callosum deformity		BGL		NMD		Normal		Total	
	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)	N	P (%)
Preterm	54	45	15	12.5	6	5	4	3.5	5	4	1	1	85	71
Term	53	43	8	6.5	3	2.5	1	1	2	1.5	8	6.5	74	59
Pot term	3	2.5	1	1	3	2.5	1	1	-	-	2	1.5	10	8.5
Total	110	90.5	24	20	12	10	6	5	7	6	11	9	169	141

\* Same patients have had more than one imaging finding abnormality in this study.

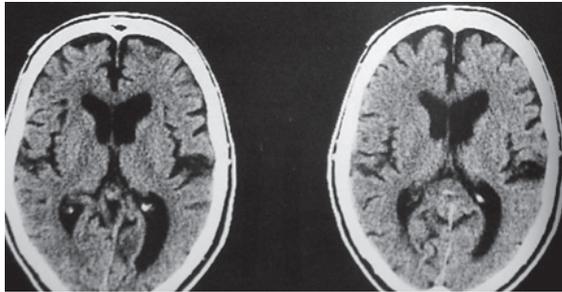


Fig-1: Brain atrophy

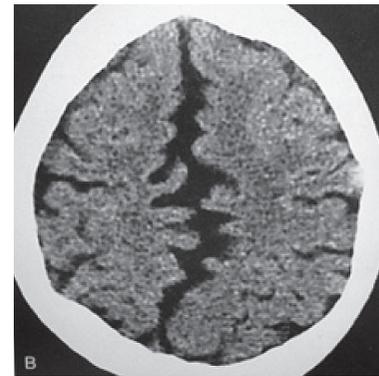


Fig-3: Axial CT scan of at the level of centrum semioval reveals interdigitation of cerebral sulci compatible with corpus callosal agenesis.

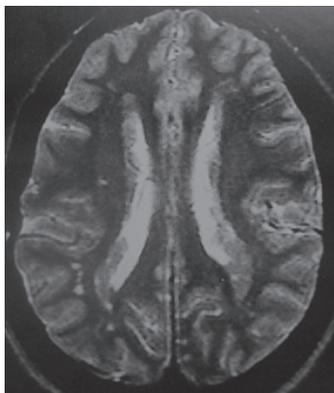


Fig-2: Axial T2 weighted image reveals periventricular subependymal nodularities due to heterotopia .

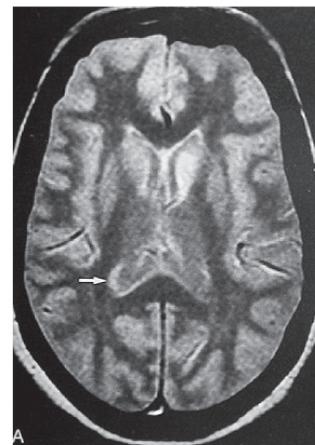


Fig-4: Axial T2 weighted image reveals hyper signal intensity in bilateral caudate nuclei and putamen.

## Discussion

According to documented reports on the association between pathologic and radiological findings, the patterns of brain insults in patients with cerebral palsy are closely related to the type of cerebral palsy, as well as the gestational age (9).

In our study more than 70% of patients belonged to the age group below the seven years, which most of them were less than 2, and there were more males than females, findings in agreement with those of Sushama and et al in Mumbai(10).

Spastic CP formed the majority of cases 90% (107/120) in this study, of which, the quadriplegic type was the most common(54%), followed by diplegic (21%), hemiplegic(15%), extra-pyramidal(8%), and the mixed type(2%); our findings, like those of Karen et al from Hong Kong(2),  $p=0.0004$ , differed those of other studies; the difference may be a result of delay in timely diagnosis of hyperbilirubinemia and its complications.

In a Swedish study, 43% of children with CP, were pre-term(11) and in the larger series of infants studied by Brawn and colleagues, the insult was believed to have accrued primarily ante partum in 51%, intra partum in 40% and post partum in 9% (10). In our investigation, 46% of infants were born preterm, 50% at term and 4% were post term( $p=0.006$ ); the difference maybe a result in enhanced health care and delivery of pregnant women in Iran.

In one study, the neuroimaging findings in patients with CP were brain atrophy, PVL, polycystic encephalomalacia, and a variety of developmental abnormalities such as polymicrogyria, schizencephally, basal ganglia lesion and NMD, which differed in full term and preterm infants with CP (11). In premature infants with paraplegic CP, the most common finding was PVL, whereas in term infants with spastic quadriplegia, a mixture of polycystic encephalomalacia, parasagittal cortical lesions and basal ganglia lesions are the most common findings (11,12).

In our study, the most findings were brain atrophy in quadriplegic patients and PVL in diplegic CP. Results of several other studies as well as those of ours, and Okomural et al's, corroborate those of others ( $P=0/04$ ) (5, 13)

Preterm type brain injury (PVL) and post hemorrhagic porencephaly, have been observed not only in children

born preterm but also in those born at term (14). In our study, these were the findings in 17.5 and 9% of pre-term and term infants respectively.

Middle cerebral artery infarcts and PVL and gliosis indicate hypoxia as being a risk factor for CP (3, 15).

Extension of CT and MRI lesions correlated with severity of neurological deficits in CP are more extensive in quadriplegic than diplogic, and in preterm rather than in term and post term delivered patients; these lesions are better demonstrated in MRIs as compared to CT scans (7, 16), a finding compatible with the results of our study (tables 2 & 3).

In this study MRI findings were closely related to gestational age; however, there are minor differences between our results and those of Okumuru et al (13).

## Conclusions

Results of this study showed radiological findings to be closely related to the type of CP and neurological deficits and the gestational age of patients with brain insults. These findings are more visible in MRI imaging than in CT scans. We believe MRI could be helpful in delineating the underlying etiology, extent, severity and timing of insult to the developing brain and prognostication in CP patients.

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