Original Research

# CLINICAL SPECTRUM, FUNCTIONAL SEVERITY AND NEUROIMAGING CORRELATES IN CHILDREN WITH CEREBRAL PALSY

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## ABSTRACT

**Background:** Cerebral palsy (CP) encompasses a heterogeneous group of neurodevelopmental disorders characterized by aberrant motor function and posture, often accompanied by sensory, cognitive and communicative impairments. Although not part of the CP definition, magnetic resonance imaging (MRI) sheds light on the localization, nature, and severity of brain compromise. This study aims to provide a comprehensive description of the clinical and neuroimaging characteristics of children with CP, highlighting the distribution of functional abilities and neuroimaging findings.

**Methods**: The present study was conducted at the Department of Pediatrics, Govt. Medical College Jammu over a period of one year with effect from September 2022 to August 2023 and included 45 patients with cerebral palsy. Data on clinical profile, functional status, and MRI findings were collected and analyzed.

**Result**s: At 5 minutes, 44.4% of patients had APGAR scores of 4-6, 28.9% had scores of 7 or above, and 2.2% had scores below 4. At 10 minutes, 40% had scores of 4-6 and 35% had scores of 7 or above. 46.7% of patients required resuscitation, with 52.4% needing bag and mask ventilation. Spastic quadriplegia was the most common type of CP (51.1%), followed by diplegia (28.9%), hemiplegia (11.1%), dyskinetic (6.7%), and ataxic (2.2%) forms. Most patients had severe functional limitations, with GMFCS Grade V (35.6%), MACS Grade IV (28.9%), CFCS Grade IV (33.3%), and EDACS Grade IV (35.6%) being most common. MRI findings showed periventricular leukomalacia (PVL) in 37.8%, cortico-subcortical lesions in 24.4%, and basal ganglia/thalamus injury in 17.8% of patients.

**Conclusion:** The study highlights the importance of early identification and intervention in cerebral palsy, with most patients presenting with severe functional limitations and abnormal MRI findings, emphasizing the need for standardized assessment and management protocols.

**Keywords:** Cerebral Palsy, Mri, Functional Profile, Brain Compromise, Movement Disorder, Posture Disorder.

## INTRODUCTION

Cerebral palsy (CP) encompasses a heterogeneous group of neurodevelopmental disorders characterized by aberrant motor function and posture, often accompanied by sensory, cognitive and communicative impairments.

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Each child with CP presents with a unique combination of neurological symptoms, motor severity and associated impairments, comprising their functional profile. [1]National guidelines recommend magnetic resonance imaging (MRI) as a diagnostic step following history taking, neurological examination, and assessment of additional impairments.[2] Similarly, international guidelines consider MRI an essential component of the diagnostic work-up .[3] Although not a defining feature of CP, MRI provides valuable insights into the localization, nature, and extent of brain compromise. The laterality of lesions affecting cerebral hemispheres influences the capacity for plasticity and ultimately, the outcome; insults to core structures critical for network building are also significant.[4] Distinct MRI patterns have been

identified and correlated with specific timing of vulnerability in various brain regions.[5] The assessment of functional abilities in children with CP is essential for guiding therapeutic interventions, predicting outcomes, and evaluating the effectiveness of interventions. Several standardized classification systems have been developed to describe the functional abilities of children with CP, including the Gross Motor Function Classification System (GMFCS) (Palisano R et al., 1997; 2007), Manual Abilities Classification System (MACS) (Eliasson AC et al., 2006), Communication Function Classification System (CFCS) (Hidecker MJ et al., 2011) and Eating and Drinking Ability Classification System (EDACS) (Sellers D et al., 2014).[6-10] These classification systems provide a framework for describing the functional abilities of children with CP and have been widely used in research and clinical practice. The GMFCS is a 5-level tool that measures gross motor function in sitting, walking, and wheelchair mobility. The MACS is a 5-level system that assesses hand and upper limb function in children aged 4-18 years. The CFCS is a 5-level system that evaluates everyday communication skills, while the EDACS is a 5-level system that assesses eating and drinking safety and efficiency. This study aims to provide a comprehensive description of the clinical and neuroimaging characteristics of children with CP, highlighting the distribution of functional abilities and neuroimaging findings. The findings of this study will contribute to the existing literature on CP and have implications for clinical practice, research, and policy-making.

## MATERIAL AND METHODS

This prospective observational study spanned over a period of six months was conducted at the Department of Pediatrics, Govt. Medical College Jammu over a period of one year with effect from September 2022 to August 2023 and included 45 patients with cerebral palsy. The study aimed to describe the clinical spectrum, functional severity and neuroimaging findings in children having Cerebral Palsy (CP) disease. We included patients who were attending the pediatric neurology clinic or admitted to the hospital diagnosed with CP aged 2-18 years. However, children with progressive neurological disorders or neurodegenerative diseases, and those with CP due to postnatal head trauma or infections (e.g., meningitis, encephalitis) were excluded. A minimum of 45 cases of CP were enrolled in the study. Accordingly, a comprehensive clinical evaluation was performed, including clinical history, neurological examination and functional assessment using the Gross Motor Function Classification System (GMFCS), Manual Abilities Classification System (MACS), Communication Function Classification System (CFCS), and Eating and Drinking Ability Classification System (EDACS). Magnetic Resonance Imaging (MRI) of the brain was performed and the reports were reviewed and classified according to the presence and type of brain abnormalities. The study was approved by the Institutional Ethics Committee and informed consent was obtained from the parents/guardians of all participants. Descriptive statistics were used to summarize the demographic and clinical characteristics, and the relationships between clinical characteristics, functional abilities, and neuroimaging findings were explored using correlation analysis and regression models. Statistical analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA).

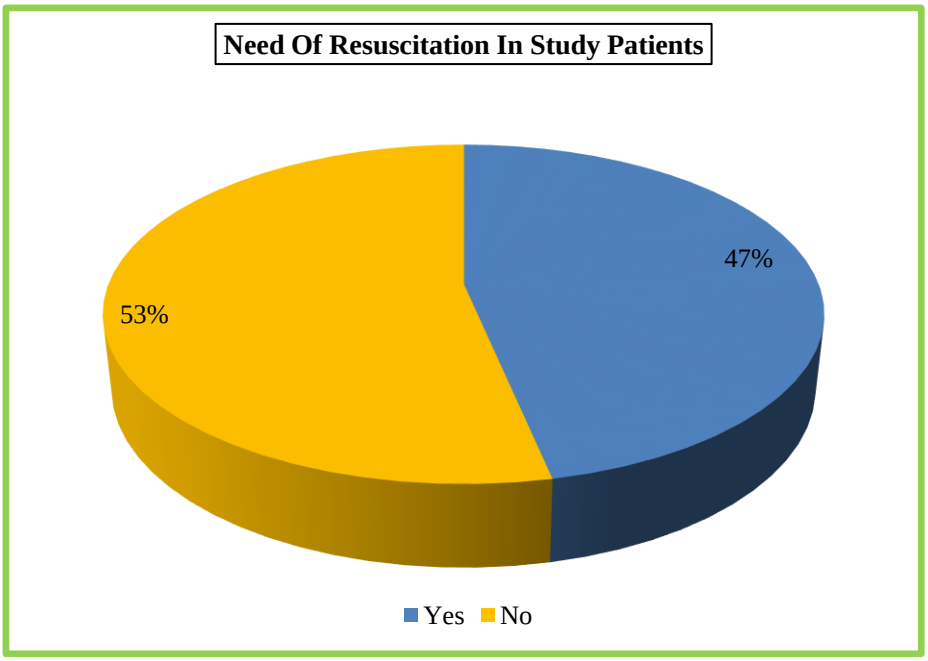
## RESULTS

A total of 45 patients with CP were included in the present study. Apgar scores were measured as part of the clinical evaluation to know the newborn's physical condition immediately after birth (see table 1).

Table 1: Apgar Score at 5 And 10 Minutes Among Study Patients

| Apgar Score | | Number | Percentage |
|---|---|---|---|
| At 5 Min | < 4 | 1 | 2.2 |
| | 4-6 | 20 | 44.4 |
| | ≥ 7 | 13 | 28.9 |
| | NA | 11 | 24.4 |
| At 10 Min | < 4 | 0 | 0.0 |
| | 4-6 | 18 | 40.0 |
| | ≥ 7 | 16 | 35.6 |
| | NA | 11 | 24.4 |

We observed that for majority of patients 44.4%, the 5-minute APGAR score was between 4-6, followed by 28.9% patients with 5-minute APGAR score of 7 or above and 2.2% patients had 5-minute APGAR score below 4. At 10 minutes, 40% patients had an APGAR score of 4-6, followed by 35% patients with an APGAR score of ≥ 7 and for 24.4% patients APGAR score was not available.




We observe that around 46.7% patients needed resuscitation as opposed to 53.3% patients who did not need resuscitation at birth.

Table 3: Distribution as per Level of Resuscitation

| Level of Resuscitation | Number | Percentage |
|---|---|---|
| Oxygen | 3 | 14.3 |
| Bag and mask | 11 | 52.4 |
| Bag and tube | 7 | 33.3 |
| Total | 21 | 100 |

Out of 21 newborns requiring resuscitation, bag and mask level of resuscitation was evident in 52.4% patients, followed by 33.3% patients with bag and tube resuscitation while only 14.3% patients were resuscitated using oxygen (see table 3).

Table 4: Clinical Type of Cerebral Palsy

| Clinical Type | Number | Percentage |
|---|---|---|
| Spastic Quadriplegia | 23 | 51.1 |
| Spastic Diplegia | 13 | 28.9 |
| Spastic Hemiplegia | 5 | 11.1 |
| Dyskinetic form | 3 | 6.7 |
| Ataxic form | 1 | 2.2 |
| Total | 45 | 100 |

We observed that majority of patients (51.1%) had spastic quadriplegia, followed by 28.9% with spastic diplegia palsy ,11.1% with spastic hemiplegia and 6.7% with dyskinetic form. Least common form was observed to be ataxic form with only 2.2% patients as shown in table 4.

Table 5: Functional Classification of Cerebral Palsy

| Functional Classification | | Number | Percentage |
|---|---|---|---|
| GMFCS Grade | I | 0 | 0.0 |
| | II | 10 | 22.2 |
| | III | 11 | 24.4 |
| | IV | 8 | 17.8 |
| | V | 16 | 35.6 |
| MACS Grade | I | 2 | 4.4 |
| | II | 11 | 24.4 |
| | III | 11 | 24.4 |
| | IV | 13 | 28.9 |
| | V | 8 | 17.8 |
| CFCS Grade | I | 6 | 13.3 |
| | II | 13 | 28.9 |
| | III | 7 | 15.6 |
| | IV | 15 | 33.3 |
| | V | 4 | 8.9 |
| EDACS Grade | I | 6 | 13.3 |
| | II | 13 | 28.9 |
| | III | 10 | 22.2 |
| | IV | 16 | 35.6 |
| | V | 0 | 0.0 |

From table 5, we observe that majority (35.6%) had GMFCS grade V, followed by 24.4% with GMFCS grade III, 22.2% with GMFCS grade II, and 17.8% with GMFCS grade IV. MACS Grade IV was evident in 28.9, followed by 24.4% MACS Grade III, 24.4% patients with MACS Grade II, 17.8% patients had MACS Grade V and 4.4% had MACS Grade I. CFCS Grade IV was found in 33.3%patients, 28.9% had CFCS grade II, 15.6% had CFCS grade III, 13.3% had CFS grade I and 8.9% patients had CFCS grade V. EDACS grade IV was found in 35.6% patients, followed by 28.9% with EDACS grade II, 22.2% with EDACS grade III, and 13.3% patients had EDACS grade I status.

Table 6: Distribution According to Spectrum of MRI Findings

| MRI Findings | Number | Percentage |
|---|---|---|
| Periventricular leukomalacia | 17 | 37.8 |
| Sequalae of intraventricular hemorrhage/ periventricular hemorrhagic infarction | 2 | 4.4 |
| Basal Ganglia/ Thalamus injury | 8 | 17.8 |
| Cortico-Subcortical lesions | 11 | 24.4 |
| Arterial infarctions | 2 | 4.4 |
| Miscellaneous | 5 | 11.1 |
| Total | 45 | 100 |

Out of 45 patients in the study, majority had MRI findings of PVL (37.8%). 11 patients had MRI findings of cortico-subcortical lesions, followed by 17.8% patients with basal ganglia/thalamus injury and 11.1% with miscellaneous findings.4.4% of patients had MRI suggestive of either arterial infarctions or were a sequale of intraventricular hemorrhage or periventricular hemorrhagic infarction (see table 6).

**Discussion**

As a part of clinical evaluation, we measured the newborn's physical condition immediately after birth, using APGAR scores wherein we found that majority of patients (44.4%) had 5-minute APGAR score between 4-6, indicating a potential risk for cerebral palsy. This was followed by 28.9% patients with 5-minute APGAR score 7 or above and 2.2% patients had 5-minute APGAR score below 4. At 10 minutes, 40% patients had an APGAR score between 4-6, followed by 35% patients with an APGAR score of ≥ 7 and for 24.4% patients APGAR score was not available. APGAR scores of less than 6 at 5 and 10 minutes clearly confer an increased relative risk of cerebral palsy, and the degree of abnormality correlates with the risk of cerebral palsy. Ehrenstein et al documented that newborns with a low 5-minute Apgar score obviously have an increased relative risk of cerebral palsy, which has been estimated to be as high as 20–100 times higher than that of infants with a 5-minute Apgar score of 7–10.[11] Even while individual risk differs, population risk also rises when the Apgar score is 3 or less at 10 minutes, 15 minutes, and 20 minutes of

a baby's life (Freeman et al).[12]The Apgar score is commonly used to measure condition at birth, but the test is often criticized for being subjective and poorly reproducible. By contrast, the need for active resuscitation is a specific sign of delayed onset of respiration and could therefore indicate recent cerebral injury, especially hypoxia–ischaemia. In the present study, we observed that around 46.7% patients needed resuscitation as opposed to 53.3% patients who did not need resuscitation. Of them bag and mask ventilation was required in 52.4%patients, followed by 33.3% patients with bag and tube ventilation and 14.3% patients requiring oxygen. Infants who require resuscitation at birth and develop symptoms of encephalopathy are at a higher risk of developing cerebral palsy, as observed in a study by Odd et al.[13] Studies suggests that resuscitation needs can be an indicator of increased risk for neonatal mortality, cerebral palsy and intellectual disabilities. It has been reported by Perlman et al, and Barber et al that approximately 6-10% of newborns require assistance to establish normal breathing, highlighting the importance of timely intervention.[14,15] However, a study by Carlo et al found that most infants who received bag and mask ventilation at birth had normal 12-month neurodevelopmental outcomes, emphasizing the need for longer follow-up to monitor potential neurodevelopmental impairments.[16]

Cerebral palsy (CP) is a neurological disorder characterized by abnormal muscle tone, posture, and movement, with four major types: spastic, ataxic, athetoid/dyskinetic, and mixed. Currently, there is no cure for CP, and management is conservative. Our study revealed that the majority of patients (51.1%) had spastic quadriplegia, followed by spastic diplegia (28.9%), spastic hemiplegia (11.1%), dyskinetic (6.7%), and ataxic (2.2%) types of CP. These findings are consistent with previous studies of Chaudhary et al., Banskota et al., Kakooza-Mwesige et al., and Sharma et al, which reported spastic quadriplegia as the most common type of CP.[17-20] Specifically, Chaudhary et al. reported spastic quadriplegia (44.44%) as the most common type, followed by diplegia (34.92%) and hemiplegia (19.4%).[17] Similarly, Ramanandi et al. found spastic diplegia (42.83%) to be the most common type, followed by spastic quadriplegia, spastic hemiplegia, dyskinetic, and ataxic types of CP.[21] The high prevalence of spastic quadriplegia in our study may be attributed to the higher incidence of perinatal asphyxia, lower prematurity rates, and a greater number of postnatal CP cases in our region.

We observed that GMFCS grade V was evident in (35.6%), followed by 24.4% with GMFCS grade III, 22.2% with GMFCS grade II, and 17.8% with GMFCS grade IV. As evident majority of our patients had GMFCS level of V and III, which is suggestive of the fact that the children had limited mobility with or without assistance from a device or physical assistance and were able to access community with help. In a study by Chaudhray et al, majority of their patients had GMFCS III classification (41.81%), followed by 28.18% patients with GMFCS IV, and 19.09% patients with GMFCS classification II which is comparable with our study.[17] In a study by Compagnone et al, majority of CP patients had GMFCS V (43.7%), followed by GMFCS II and I cases.22 In comparison to Australian, European, or North American cohorts, a higher percentage of children with GMFCS scores of IV or V were observed in Asian or African childcare facilities (Leebrun et al, Donald et al).[23,24] The significant number of moderate to severe forms in our study is supported by the prevalence of quadriplegic presentation. In order to see the functional distribution in our area more clearly, a community- or population-based study must be conducted. In our study, MACS Grade IV was evident in 28.9, followed by 24.4% MACS Grade III, 24.4% patients with MACS Grade II, 17.8% patients had MACS Grade V and 4.4% had MACS Grade I. CFCS Grade IV was found in 33.3%patients, 28.9% had CFCS grade II, 15.6% had CFCS grade III, 13.3% had CFS grade I and 8.9% patients had CFCS grade V. EDACS grade IV was found in 35.6% patients, followed by 28.9% with EDACS grade II, 22.2% with EDACS grade III, and 13.3% patients had EDACS grade I status. Compagnone et al, in their study reported that majority of their patients (39.1%) had MACS level V, followed by 17.2% and 14.9% patients with MACS III and II respectively, which is comparable with our study. They reported that CFCS level V was evident in 20.7% of their patients, followed by CFCS level IV and II.[22] They also assessed the relationship between the GMFCS-E&R, MACS, and CFCS and reported a statistically significant relationship between the three functional classifications, although only at the lowest level of function (level V).[22] This is consistent with the "all V" functional profile, which Hidecker et al define as a functional pattern defined by a lack of participation in daily life and a near total reliance on others for all activities (low functioning cluster).[25] Furthermore, our study revealed that periventricular leukomalacia (PVL) was the most common MRI finding, observed in 37.8% of patients, followed by cortico-subcortical lesions (24.4%), basal ganglia/thalamus injury (17.8%), and miscellaneous lesions (11.1%). The distribution of MRI findings suggests that the timing and nature of brain insults play a crucial role in determining the type and extent of brain damage. The periventricular white matter is particularly vulnerable to injury during the early third trimester or in premature infants, leading to PVL. In contrast, gray matter, including cortical gray matter and deep gray nuclei like the thalamus and basal ganglia, is more susceptible to injury at the end of the third trimester or in term-born neonates.

Arterial territory infarcts, particularly in the middle cerebral artery (MCA) region, are more common in term-born children with cerebral palsy, although they can also occur in very preterm infants. Our findings are consistent with previous studies, such as Bax et al., which reported white matter damage of immaturity (WMDI, including PVL) as the most common MRI finding (42.5%), followed by basal ganglia lesions (12.8%), cortical/subcortical lesions (9.4%), malformations (9.1%), focal infarcts (7.4%), miscellaneous lesions (7.1%), and normal MRI findings (11.7%), which is akin to our study.[26] The similarity in findings suggests that the patterns of brain injury in cerebral palsy are relatively consistent across different populations.

## CONCLUSION

The present study revealed that APGAR scores for most patients were between 4-6 at 5 and 10 minutes, suggesting a potential risk for CP. The need for resuscitation was also a significant indicator of risk, with around half of the patients requiring some form of intervention. Furthermore, the majority of patients had spastic quadriplegia clinical manifestation, followed by spastic diplegia and hemiplegia, consistent with previous studies. Most patients had severe functional limitations, with GMFCS grade V and III being the most common. The Manual Ability Classification System (MACS), Communication Function Classification System (CFCS), and Eating and Drinking Ability Classification System (EDACS) also showed a similar trend, with most patients having significant functional impairments. Periventricular leukomalacia (PVL) was the most common MRI finding, followed by cortico-subcortical lesions and basal ganglia/thalamus injury, indicating that the timing and nature of brain insults play a crucial role in determining the type and extent of brain damage. We suggest for the implementation of routine developmental screening and surveillance that can help identify high-risk infants and thereby enabling timely intervention.

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