

Clinico-Radiological Profile of Children Attending the Cerebral Palsy Clinic - A Prospective Survey

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Abstract

Introduction Cerebral palsy is a static motor encephalopathy associated with multiple co-morbidities. An interdisciplinary approach is needed to minimize the disability and ultimately improve the quality of life.

Aims and Objectives: To assess the clinical, radiological findings and functionality and improvement with therapy in children attending the Cerebral Palsy Clinic.

Methods: Prospective, observational study was conducted over a period of 8 months at the Cerebral Palsy Clinic. A total of 45 children with suspected cerebral palsy were enrolled after clinical and radiological diagnosis by a team of paediatric neurologists, orthopedicians, physiotherapists and occupational therapists. An individualized treatment plan was made Application of applying the Gross Motor Function Classification System(GMFCS) scale. Data collected was analyzed with the SPSS software. Qualitative data collected as frequency and percentage tables.

Results: Age of presentation was higher in the preschoolers (1 - 4 years) 42.22% with Male: Female ratio of 1.8:1. The presenting complaints were global developmental delay (46.67%), communication disorders (26.67%), preferential handedness (17.78%) and epilepsy (13.33%). The high risk factors were prematurity (33.33%), asphyxia (5.56%), hyperbilirubinaemia (13.33%). On examination 46.67% had microcephaly and 31.11% had a GMFCS score of 5. Topographically cerebral palsy noted as spastic diplegic, quadriplegic and hemiplegic in 31.11%, 22.22% and 13.33% respectively. MRI Brain was abnormal in 51.11% with periventricular leucomalacia (33.33%) and sub cortical damage (11.11%). Interestingly secondary autistic features were noted in (26.67%) of children with cerebral palsys. On follow up notable qualitative improvement in seizures control (28.89%), locomotion ((48.89%) and muscle strength (46.67%) was seen.

Conclusion: 50% of cerebral palsies have no identifiable underlying etiology. Global developmental delay was the commonest presentation in male preschoolers. Spastic diplegia was the commonest type of CP with a consistent finding of periventricular leucomalacia on the MRI. After 3 weeks of therapy qualitative improvements were seen in majority of the cases.

Keywords: Cerebral Palsy; Clinico-Radiological Profile; Prospective Survey; Periventricular Leucomalacia; Spastic Diplegia

Review of Literature

Cerebral palsy (CP) was first described in 1862 by an orthopedic surgeon named William James Little, as motor disorder resulting from a insult to the developing brain [1-4]. Cerebral palsy is a static encephalopathy and may be defined as a non-progressive disorder of posture and movement, often associated with epilepsy and abnormalities of speech, vision and intellect resulting from a defect or lesion of the developing brain.

Etiology of CP

There are various risk factors proposed for CP. These can be broadly classified as Antepartum, intrapartum and postpartum causes. The etiology of CP is very diverse and multifactorial. The causes are congenital, genetic, inflammatory, infectious, anoxic, traumatic and metabolic. The injury to the developing brain may be prenatal, natal or postnatal. As much as 75% - 80% of the cases are due to prenatal injury with less than 10% being due to significant birth trauma or asphyxia [5]. The most important risk factor seems to be prematurity and low birth weight with risk of CP increasing with decreasing gestational age and birth weight. Cerebral palsy is seen in 10 - 18% of babies in 500 999 grams birth weight [6]. CP occurs more commonly in children who are born very prematurely or at term. Although term infants are at relatively low absolute risk, term births constitute the large majority of all births, as well as approximately half of all births of children with cerebral palsy. Prenatal maternal chorioamnionitis is also a significant risk factor accounting for as much as 12% of cerebral palsy in term infants and 28% in premature infants [7,8]. Cystic periventricular leukomalacia (CPVL) is a risk factor with 60% - 100% of patients with CPVL developing CP [8]. Prenatal risk factors include intrauterine infections, teratogen exposures, placental complications, multiple births, and maternal conditions such as mental retardation, seizures, or hyperthyroidism. The incidence of CP is higher among twins and triplets than singletons. Perinatal risk factors are infections, intracranial hemorrhage, seizures, hypoglycemia, hyperbilirubinemia, and significant birth asphyxia. Perinatal arterial ischemic stroke has been identified as another probable cause which leads to hemiplegic CP in many infants. Postnatal causes include toxic, infectious meningitis, encephalitis, traumatic such as drowning. There is also a relation between coagulopathies causing cerebral infarction and particularly hemiplegic type of CP. Postnatal events account for 12% - 21% of CP. But in a large number of cases, the cause of CP remains unknown.

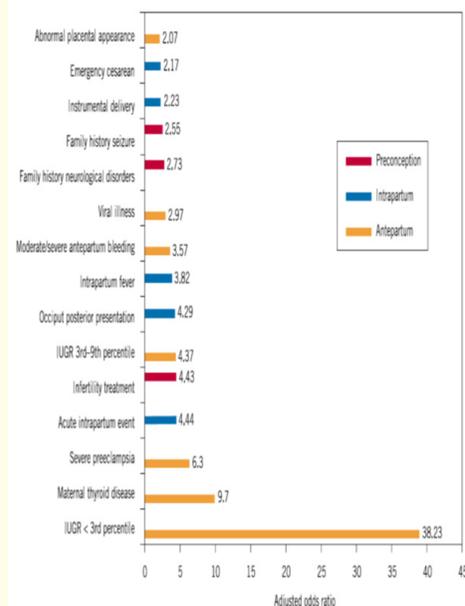


Figure 1: Risk factors for Cerebral Palsy [2,3].

Pathophysiology of CP

Hypoxia/ischemia related brain damage is a major factor for morbidity and mortality associated with CP. Congenital damage and damage due to infection and inflammation are also major factors in the pathology of CP. Following flow chart summarize pathophysiology of Cerebral palsy.

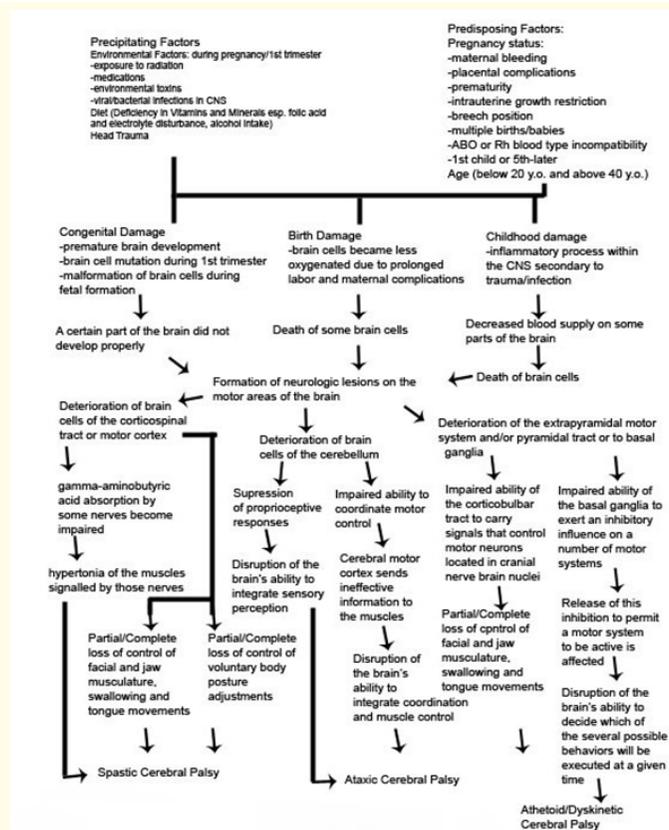


Figure 2: Pathophysiology of CP [4].

Classification of Cerebral palsy

4 types of cerebral palsy include:

- 1) Spastic (70 - 80% of all): Defined as increased muscle tone of clasp knife quality, increased reflexes with tendency to clonus, and tendency for contractures; Flexion contractures at elbow, difficulty with pronating or supinating forearms; Difficulty with long sitting because of hamstring contractures, difficulty changing diapers because of decreased range in abduction of hips; Scissoring in lower extremities, toe walking gait Caution: idiopathic toe walking with ability to walk, climb and run is more often a marker for a developmental disability or autism, or congenital tight Achilles tendons.
- 2) Athetoid (10 - 20% of all): Defined as dominated by athetoid involuntary movements of hand, feet, arms, muscles of the face or tongue. Movements are usually writhing in nature, exacerbated by stress, disappear in sleep.
- 3) Hypotonic/Ataxic (5 - 10% of all): Least common type of CP, manifested by poor coordination, unsteady gait, difficulty with rapid or precise movements.
- 4) Mixed CP: the most common form includes spasticity and dystonic/athetoid movements.

Classification of Cerebral palsy

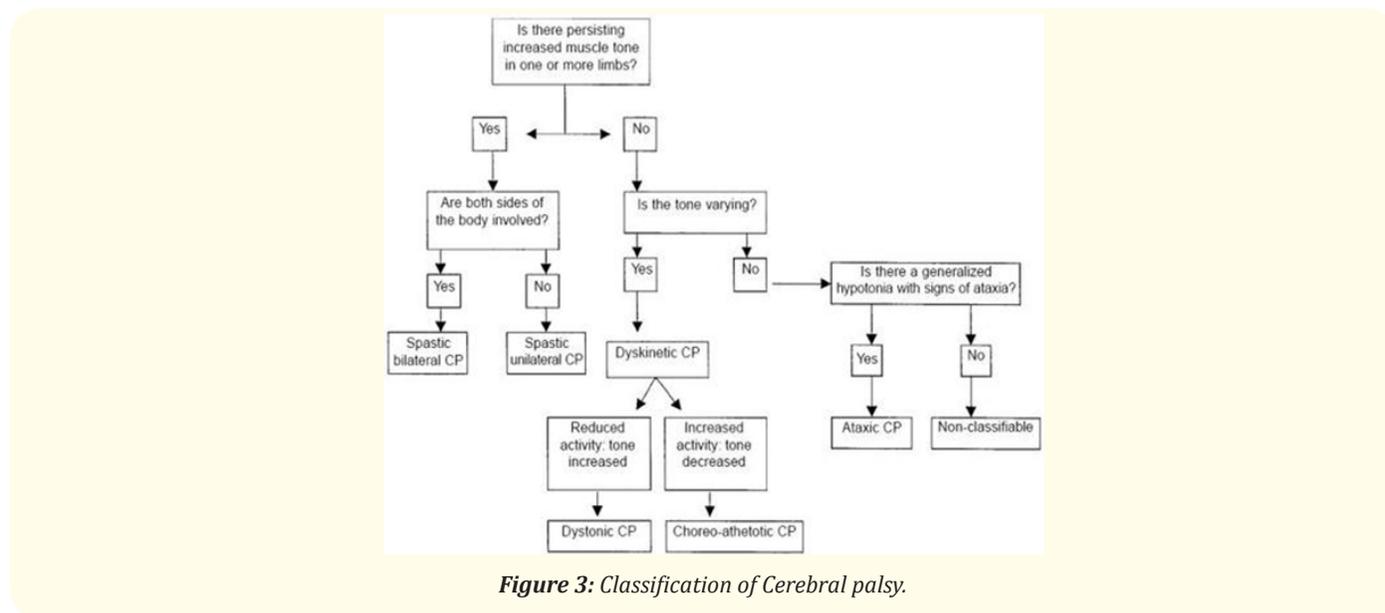


Figure 3: Classification of Cerebral palsy.

Classification of Activity Limitation: Gross Motor Function Classification System (GMFCS)

In the past, patients’ gross motor functional limitations were categorized as mild, moderate, and severe. In 1997 a hallmark paper was published by Palisano and colleagues [9] that provided a new classification system for gross motor function in children with CP, the Gross Motor Function Classification System (GMFCS). This system rated patients’ ambulatory function, including use of mobility aids and performance in sitting, standing, and walking activities. The original GMFCS had some limitations. These limitations included an upper age limit of 12 years (before adolescence) and the necessity of using a single rating to describe a child’s ambulatory performance across different terrains and distances, resulting in a tendency of parents and therapists to rate a child based on their best capability rather than their typical performance when forced by the rating scale to choose a single category [10]. These issues were considered and addressed in an updated version of the scale [11]. The GMFCS-Expanded and Revised includes children up to 18 years of age. The descriptions of gross motor function were also revised to incorporate aspects of the framework of the ICH and recognizing that a child’s environment and other factors may affect gross motor performance.

The GMFCS-ER provides a method for communicating about gross motor function, based on the use of mobility aids and performance in sitting, standing, and walking activities. It is intended to classify a patient’s level of gross motor function based on his or her typical performance, rather than their best capability. It classifies gross motor function on a 5-point ordinal scale, with descriptions of skills provided for 5 age groups: less than 2 years of age, 2 to 4 years of age, 4 to 6 years of age, 6 to 12 years of age, and finally 12 to 18 years of age. In general, the levels are as follows:

- Level I: Walks without limitations.
- Level II: Walks with limitations.
- Level III: Walks using a hand-held mobility device.
- Level IV: Self-mobility with limitations; may use powered mobility.
- Level V: Transported in a manual wheelchair.

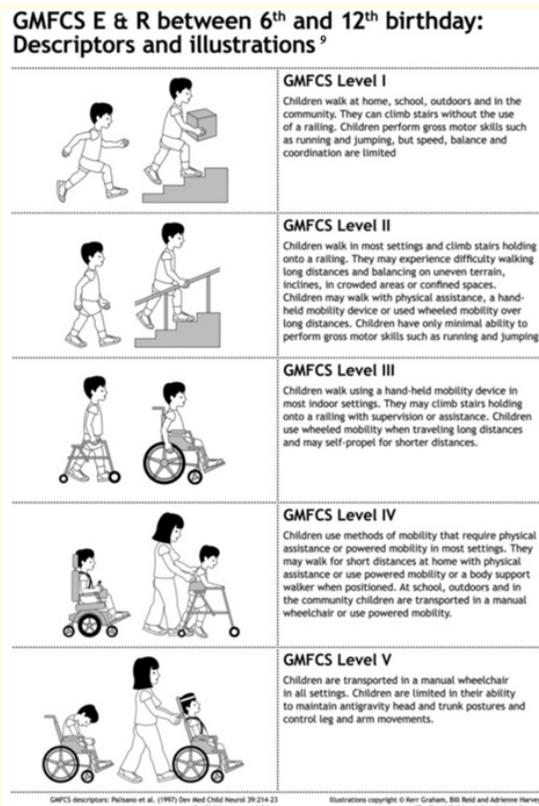


Figure 4: GMFCS-ER6 to 12 years of age [9].

Interventions in Cerebral Palsy

Therapeutic management

Rehabilitation can be defined as the multi- and interdisciplinary management of a person’s functioning and health. Its goal is to minimize symptoms and disability (Stucki., *et al.* 2003). In pediatric rehabilitation, best practice service delivery is considered to be family-centered, incorporate instruction and practice into daily activities and routines, and promote outcomes that are meaningful to the child and family life. Common treatment options to relieve muscle dysfunction include physiotherapy, occupational therapy, medical therapy and surgery. The children should also have access to orthotic services, a paediatric speech and language therapist a psychologist and special teachers.

1. Bobath/Neurodevelopmental therapy (NDT)	2. Conductive education
3. Sensory integration	4. Aim-oriented management
5. Advance neuromotor rehabilitation	6. Biofeedback
7. Dohsa-Hou (a Japanese psychorehabilitation technique)	8. Electrical stimulation
9. Early intervention (e.g. Portage project)	10. Functional physical therapy
11. Movement Opportunities via Education (MOVE)	12. Patterning (Doman-Delacato, i.e. IAHP/BIBIC/Brainwave)
13. Pelvic positioning	14. Physical activity training
15. Strength training	16. Targeted training
17. Vojta	18. Training program (15 modalities) by Phelps
19. Recreational therapies (e.g. hippotherapy/saddle riding, hydrotherapy/swimming programmes)	20. Alternative therapies (e.g. hyperbaric oxygen therapy, acupuncture, and osteocraniosacral therapy)

Table 1: List of Therapeutic approaches to the management of CP.

Because of complexities of management of children with cp various methods are described for the rehabilitation. The efficacy of only few such methods are established while other methods failed to established by scientific research. Some of these methods are briefly described in following pages.

Traditional Physiotherapy and Occupational Therapy

Traditional physiotherapy used in children with cerebral palsy (CP) has been shown to improve muscle strength, local muscular endurance, and overall joint range of motion [12,16-18]. A program of progressive resistive exercises is used to improve muscle strength [13,19]. A program that use slow resistance and more repetitions will enhance local muscular endurance. The physical therapist carries out repetitive passive range of motion exercises to improve and maintain joint mobility. Passive, static, gentle stretches are performed on individual joints to decrease and prevent joint contractures.

Traditional occupational therapy is a recommended component of an interdisciplinary team approach to the treatment of children with CP [20,21]. Occupational therapist (OT) works with children with CP in improving fine motor abilities, especially the use of upper extremity in performing activities of daily living.

Neurodevelopmental Treatment (NDT)

This therapeutic approach was developed by Berta and Karl Bobath in the 1940s, based on their personal observations working with children with cerebral palsy [16,22]. The basis of NDT approach as conceptualized by Bobaths is that the motor abnormalities in children with CP are due to failure of normal development of postural control and reflexes because of the underlying dysfunction of the central nervous system [14,22,23]. The aim of the NDT approach is to facilitate normal motor development and function and to prevent development of secondary impairments due to muscle contractures and joint and limb deformities.

Sensory Integration (SI)

The theory of sensory integration was originally developed by A. Jean Ayres in the 1970s [24]. The principles of SI theory are used by occupational therapists in developing treatment approaches for children with sensory processing difficulties, including CP. As conceived by Ayres, the SI model was developed to treat learning disabilities. SI theory is based on the hypothesis that in order to develop and execute a normal adaptive behavioral response, the child must be able to optimally receive, modulate, integrate, and process the sensory information [24,25]. Many children with learning disabilities, cerebral palsy and other neurodevelopmental disabilities have associated sensory difficulties. The SI approach attempts to facilitate the normal development and improve the child's ability to process and integrate sensory information (visual, perceptual, proprioceptive, auditory, etc.) [24]. It is proposed that this will allow improved functional capabilities in daily life activities.

Electrical Stimulation

The goal of the electrical stimulation is to increase muscle strength and motor function. Electrical stimulation is provided by TENS (transcutaneous electrical nerve stimulation) unit which is portable, non-invasive and can be used in the home-setting by parents or the patient [26]. Neuromuscular electrical stimulation (NMES) involves application of transcutaneous electrical current that results in muscle contraction [26]. NMES has been postulated to increase muscle strength by increasing the cross-sectional area of the muscle and by increased recruitment of type 2 muscle fibers.

Patterning

The concept of patterning is based on theories developed by Fay, Delacato, and Doman in the 1950s and 1960s [16]. Patterning is based on the principle that typical development of the infant and child progresses through a well-established, pre-determined sequence; and failure to normally complete one stage of development therefore impairs or inhibits the development of the subsequent stage [14,16].

It was hypothesized that typical motor development can be facilitated in the brain injured children by passively repeating the sequential steps of typical development, a process called patterning [14,16]. Parents and other care givers are taught to carry out patterning at home. This approach is labor intensive and time consuming as it requires multiple sessions every day. Effectiveness of patterning has not been established and its use in children with CP is not recommended.

Conductive Education

CE was developed by Peto in the 1940s [14,16]. It is based on the concept that children with motor disabilities learn the same way as those with no disability. CE is carried out by trained “conductors” who use repeated verbal reinforcement to promote and facilitate intended motor activity by the child. Participation in CE requires reasonable cognitive abilities to comprehend the verbal instructions. The idea is to develop independence in daily activities by the child by facilitating all aspects of child’s development. The child is encouraged to participate and practice all daily activities to the best of his or her abilities [27,28].

Constraint-Induced Therapy

Constraint-induced therapy is used to improve the use of affected upper extremity in a child with hemiplegic CP [18,29,30]. The normally functioning or stronger upper extremity is immobilized for a variable duration in order to force the use of the affected or weaker upper extremity over time.

Hippotherapy

Therapeutic horse-back riding has been shown to improve muscle tone, balance, and postural control in children with CP. Children with CP enjoy horse riding and it also provides a setting for increased social interaction and psychosocial development.

Hyperbaric Oxygen Therapy

Use of hyperbaric oxygen therapy (HBOT) in children with CP is based on the hypothesis that HBOT will increase the oxygen available to the neurons surrounding the injured area of the brain and revive these dormant neurons [14]. Additionally, HBOT is postulated to decrease brain edema by inducing cerebral vasoconstriction. Typically, HBOT is administered at 1.75 atmospheric pressure, each session lasting about an hour, given 1 - 2 time per day for 5 - 6 days per week, initially for 40 treatments [14,16]. Potential complications of HBOT include ear pain, bleeding from ears, tympanic membrane perforation, myopia, pneumothorax, and seizures [11,31].

Vojta Method

Vojta approach is based on the observation that children with CP exhibit many of the reflexes seen in normal newborns [14,16,18]. According to Vojta, the persistence of these newborn reflex patterns in a child with CP interferes with postural development. It is postulated that with appropriate stimulation, the newborn reflex pattern can be provoked and activated in a child with CP, thereby facilitating the development of reflex locomotion [14,16].

Because of the complexities of the management of children with cerebral palsy, a number of various therapeutics interventions have been used by professionals and families alike. The efficacy of only a few such interventions has been established by scientific research while many others have no established effectiveness in cerebral palsy management.

Neuroimaging in Cerebral Palsy

Neuroimaging, especially magnetic resonance imaging (MRI), plays an increasing role in the diagnosis of CP [33]. It has the potential to visualize physiological and pathological morphological changes during brain development [34]. The human brain undergoes complex organizational changes during development, in and ex utero. Pathogenic events affecting the developing brain cause abnormalities/lesions, the patterns of which depend on the stage of brain development. Cortical neurogenesis takes place predominantly during the 1st and 2nd trimester and is characterized by proliferation, migration, and organization of neuronal precursor cells, then neuronal cells.

Brain pathology is characterized by maldevelopments caused by genetic or acquired impairments [35,36]. From the late 2nd and early 3rd trimester onwards, when the ‘gross architecture’ of the brain (neural cyto- and histogenesis) is established, growth and differentiation events (axonal and dendrite growth, synapse formation, and myelination) are predominant which persist into postnatal life. Disturbances of brain development during this period most often result in lesions/defects.

Their causes are multiple and key factors are inflammation with excessive cytokine production, oxidative stress, and excess release of glutamate, triggering the excitotoxic cascade, factors which are induced by infectious and hypoxic-ischemic mechanisms [37-39]. A potentiation of single effects can be assumed [40-43]. During the early 3rd trimester, and in the preterm-born infant, Periventricular white matter (PWM) is especially affected. Towards the end of the 3rd trimester, and in the term-born infant, grey matter, either cortical or deep grey matter (e.g. basal ganglia and thalamus) appear to be more vulnerable [42-47].

Infarcts of the middle cerebral artery (MCA) are reported mainly in term or near-term born infants [48,49] although they may occur in the very preterm infant [40]. Thus, different patterns of brain abnormalities (whether maldevelopments or lesions in the sense of defects) characterize different timing periods of compromise. Taking into account that CP originates from an interference, lesion, or abnormality of the developing brain, it can be assumed that MRI has the potential to identify the lesion or abnormality and, thus, can help us to understand the timing of CP origin.

Review by Krägeloh-Mann., *et al.* [32] found that periventricular White Matter lesions were the most common pattern reported, in around 60% of children with CP (excluding ataxic CP) and by far the predominant MRI finding in preterm CP (approximately 90%). PVL and/or consequences of IVH of different topography and extent easily explain the CP-subtypes reported. Cortical or deep grey matter lesions represent the second most frequent pattern in CP (around 20%, excluding ataxic CP). They were the typical lesions of term-born children with athetoid CP or severe Bilateral Spastic-CP (‘tetraplegia’ or ‘quadriplegia’), reported in 44% of these children.

Brain maldevelopments, indicating 1st and 2nd trimester origin, were rather rare, reported in less than 10% of children with CP. They occurred six times more often in term than in preterm-born children with CP. The CP-subtype with a somewhat higher proportion of these patterns was Unilateral Spastic-CP (spastic hemiplegia), where cortical dysplasias, unilateral schizencephaly, and other focal malformations accounted for 16% of cases, and also ataxic CP where 17% of cases were reported to have cerebellar hypoplasias.

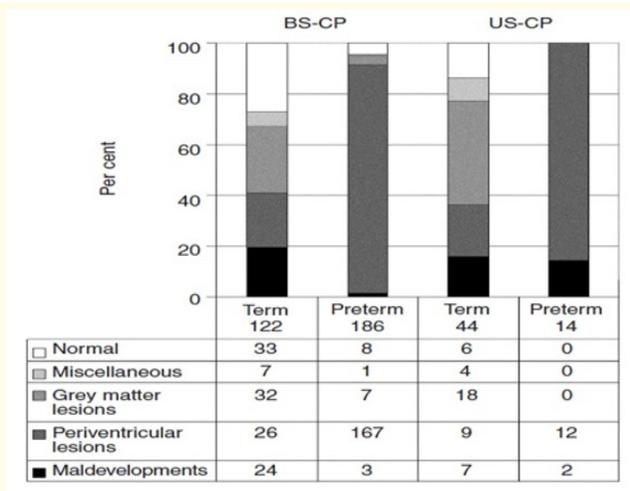


Figure 5: MRI pattern distribution in two major CP subtypes. Bilateral spastic cerebral palsy (BS-CP) and unilateral spastic cerebral palsy (US-CP) according to gestational age grouping term/preterm [32].

Results and Observations

Total 45 children with cerebral palsy were studied. Out of which, 29 were male (64.44%) and 16 were females (35.56%).

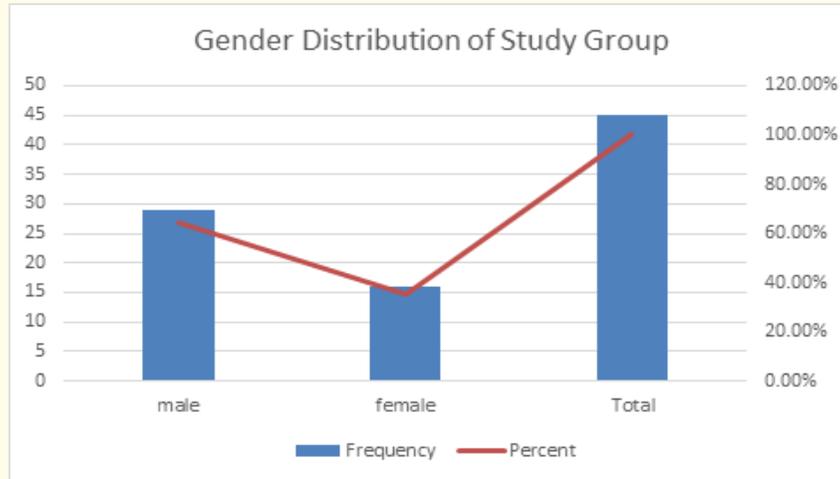


Figure 6: Gender Distribution of Study population.

Study group were studied in 4 age groups as less than 1 year, 1 year - 4 year, 5 year - 9 years, and 10 years and above. Distribution in each group is as below:

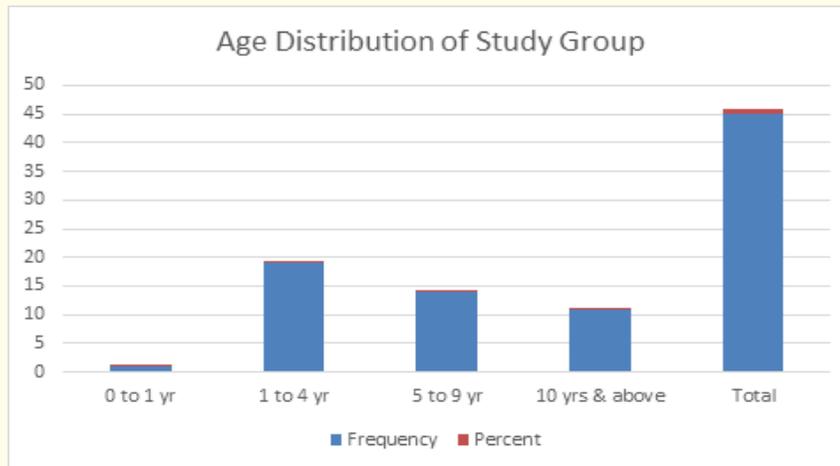


Figure 7: Age distribution of study groups.

Age	Frequency	Percentages
0 to 1 yr	1	2.22%
1 to 4 yr	19	42.22%
5 to 9 yr	14	31.11%
10 yrs and above	11	24.44%
Total	45	100.00%

Table 2: Age distribution of study population attending the cerebral palsy.

Almost all children (93.33%) presented with developmental delay. Commonest presentation is developmental delay without any associated problems followed by developmental delay with other problems (feeding difficulty, anemia, infection etc).

Presenting Complaints	Frequency	Percentages
Developmental Delay	21	46.67%
Developmental Delay and seizures	4	8.89%
Developmental Delay, seizures and involuntary movements	1	2.22%
Developmental Delay, seizures and others	4	8.89%
Infection	1	2.22%
Developmental Delay and involuntary movements	3	6.67%
Developmental Delay and other	8	17.78%
Other	3	6.67%
Total	45	100.00%

Table 3: Presenting complaints in study population.

Commonest associated problem was speech difficulty followed by combination of speech difficulty and epilepsy. 75.56 % required some form of assistance for daily activity.

While analyzing etiological factors in most of the patients consanguinity was absent in 95.56% and most of them (80%) didn't have any a significant family history or antenatal history (82.22%). 80% were born by normal vaginal delivery and 66.67% were of term gestation. However 55.55% did not cry after birth and 64.44% had some form of significant postnatal complications like hyperbilirubinemia, sepsis, respiratory distress (Table 4).

Postnatal Complications	Frequency	Percent
Respiratory distress	3	6.67%
1,3,7	1	2.22%
Respiratory distress and hyperbilirubinemia	2	4.44%
Respiratory distress and other	1	2.22%
Mechanical ventilation	1	2.22%
Sepsis	1	2.22%
Sepsis and Intracranial bleed	1	2.22%
Sepsis and Hyperbilirubinemia	1	2.22%
Sepsis and seizure	1	2.22%
Sepsis and other	1	2.22%
Hyperbilirubinemia	6	13.33%
ET transfusion	3	6.67%
Other	2	4.44%
Unknown	5	11.11%
insignificant	16	35.56%
Total	45	100.00%

Table 4: Perinatal events in study population.

On developmental assessment most of the children with history of developmental delay had moderate to severe developmental delay and most of them had moderate to severe motor delay (75.56%).

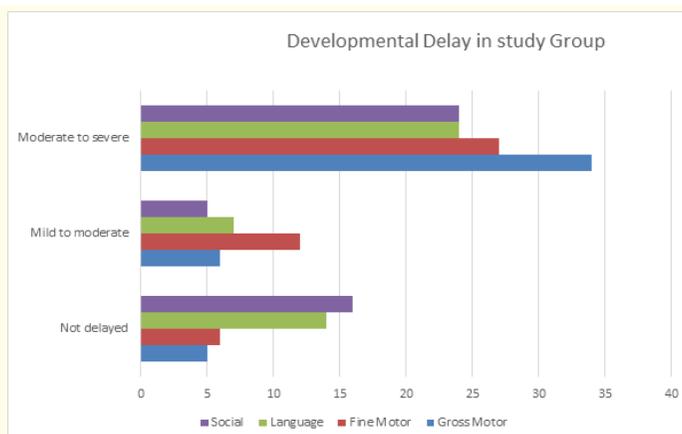


Figure 8: Developmental Delay in study Group.

51.11% had minimal social interaction and eye to eye contact was absent in 26.67%, 40 % had good vocabulary, bowel control was achieved present in 42.22 % patients.

All patients assessed for Gross Motor Function Classification System (GMFCS) scale and most of them were belonging to class 4 and 5 indicating severe impairment.



Figure 9: GMFCS scale assessment in study population.

On central nervous system examination most patients were spastic (86.67%). Involuntary movements were seen only in 9 patients (20%).

On neuroimaging 51.11% patients had abnormal MRI findings while normal MRI was reported only in 4.44% patients. Details are tabulated as below:

Types of CP	Frequency	Percent
Hemiplegic	6	13.33%
Diplegic	14	31.11%
Spastic quadriplegic	10	22.22%
Dyskinetic	2	4.44%
Mixed	5	11.11%
Triplegic	2	4.44%
CP mimic	6	13.33%
Total	45	100.00%

Table 5: Topographic classification of children with cerebral palsy.

MRI Findings	Frequency	Percent
White matter damage and periventricular leukomalacia	15	33.33%
Basal ganglia damage	2	4.44%
Focal infarct	1	2.22%
Cortical/subcortical damage	5	11.11%
Malformation	1	2.22%
Miscellaneous	1	2.22%
Normal	2	4.44%
MRI not done	18	40.00%
Total	45	100.00%

Table 6: MRI findings in study population.

CT scan was done in 4 patients out of whom two patients had normal study. Abnormal EEG was documented in 7 patients (15.56%). Most of the patients were not evaluated by BERA but 2 patients were diagnosed to have conductive hearing loss and 1 patient was diagnosed to have sensorineural hearing loss on BERA. Ophthalmic problems like squint and optic atrophy were seen in (8.89%) and (2.22%) respectively. After starting appropriate intervention in patients 38 patients (84.44%) shown the improvement in the activity of daily living, while locomotion was improved to some extent in 22 patients (48.89%). Some change was observed in muscle power in 21 patients (46.67%) and in 13 patients (28.89%) good seizure control was observed. There was no change in GMFCS score in most of the patients after appropriate intervention and improvement was a qualitative finding.

Discussion

The prematurity is the commonest risk factor for developing cerebral palsy but the majority (66.67%) of affected children in our study were full- suggesting that in our country perinatal events have an important role in neonatal outcome. We observed that spastic diplegic CP was the commonest type of CP which was contradictory to other studies [53,52]. Literature mentions that up to 50% of CP cases have no identifiable underlying etiology [54] which was again proved in this study. Developmental delay was the commonest presentation in this study which in accordance with other studies [13,53]. Most of the children with developmental delay had moderate to severe motor delay (75.56%). Spastic diplegic CP is the commonest type in our study which contradicts the findings by Singhi, *et al.* [55] who founded spastic quadriplegia as the commonest type. Also incidence of microcephaly was observed in 21 patients (46.67%) in our study which is lesser than other studies [48,55].

Commonest MRI findings in our study was white matter damage with periventricular leucomalacia which in concurrence with the study done by Yokochi., *et al.* [56] and Okumura., *et al* [57].

Appropriate intervention in patients showed qualitative improvement in activities of daily living, muscle power and locomotion. However further follow-up analysis is required to see any further improvement.

Summary and Conclusion

1. 50% of CP cases have no identifiable underlying etiology.
2. Moderate to severe motor developmental delay was the commonest presentation.
3. Spastic diplegic CP is the commonest type in our study.
4. All patients were assessed for GMFCS levels and most of them were belonged to Class 4 and 5 indicating severe impairment.
5. Commonest MRI findings in our study was white matter damage with Periventricular leucomalacia.
6. Appropriate intervention showed qualitative improvement in activity of daily living, muscle power and locomotion. However further follow up and analysis is required to see any further improvement.

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