*Original Article*

# Epilepsy in Children With Cerebral Palsy

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**ABSTRACT**

To study the spectrum of epilepsy in children with cerebral palsy, 105 consecutive children with cerebral palsy and active epilepsy, between 1 and 14 years of age, were studied prospectively. A detailed history and examination, electroencephalography (EEG), and computed tomography (CT) were done in all cases. The social quotient was assessed using the Vineland Social Maturity Scale. A retrospective cohort of 452 cases of cerebral palsy was studied to find the prevalence of epilepsy in cerebral palsy. A control group of 60 age-matched children with cerebral palsy but no epilepsy was also studied for comparison of the social quotient. Of the 105 children, 65 were male, 40 of 105 (38%) had a history of birth asphyxia. The mean age of onset of seizures was 18.9 months; 64 (60.95%) had seizure onset before 1 year of age. Children with myoclonic seizures ($P < .05$) and infantile spasms ($P < .01$) had seizure onset significantly early in life. Generalized seizures were the most common, followed by partial seizures, infantile spasms, and other myoclonic seizures. Seizures were controlled in 45 (58.1%) children, and polytherapy was required in 40 children. EEG and CT abnormalities were seen in 70.5% and 61% of the children. Seizure control was achieved in 74% of the patients with a normal to borderline social quotient compared with 48.7% with a social quotient less than 70. Social quotient values had a positive correlation with age of onset of seizures ($P < .01$) and with better control of seizures ($P < .01$). Of the cohort of 452 children, 160 (35.4%) had epilepsy. The maximum incidence (66%) was seen in children with spastic hemiplegia, followed by quadriplegia (42.6%) and diplegia (15.8%). Epilepsy in cerebral palsy is seen in about one third of cases; it is often severe and difficult to control, particularly in children with mental retardation. (*J Child Neurol* 2003;18:174–179).

Epilepsy is an important problem in children with cerebral palsy.[1] At times, it may be more disabling than the motor disorder per se. The incidence of epilepsy in children with cerebral palsy has been reported variably from 15 to 41.8%.[2–4] In developing countries, including India, the incidence and spectrum of cerebral palsy are different from those in the West.[5,6] Hence, the type of epilepsy occurring in children with cerebral palsy is also expected to be somewhat different. It is not clear whether children with cerebral palsy and epilepsy reflect a more severe manifestation of the spectrum of cerebral palsy than those without epilepsy. This study was undertaken to examine the spectrum of various types of epilepsies in children with cerebral palsy and also to see whether there was any significant difference between those children with cerebral palsy who had epilepsy versus those who did not.

## METHOD

We studied two sets of children. Group A consisted of 105 consecutive cases of cerebral palsy and active epilepsy between 1 and 14 years of age. These children were enrolled from the pediatric outpatient department of the Postgraduate Institute of Medical Education and Research and from the rehabilitation center—Prayas, in Chandigarh, India, and were studied prospectively. Group B consisted of a retrospective cohort of 452 children with cerebral palsy being followed at Prayas. Both groups of children had been brought or referred to Prayas primarily because of cerebral palsy. They consisted of children brought from the community by their parents as well as those referred by practitioners in the region. Group A consisted of children with cerebral palsy and seizures brought for the first time to the center during the study period, whereas group B was composed of children with cerebral

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**Table 1. Prevalence of Epilepsy in Subtypes of Cerebral Palsy**

| *Subtypes of Cerebral Palsy* | *No. of Children (%)* | *No. With Epilepsy (%)* |
|---|---|---|
| Spastic quadriplegia | 204 (45.1) | 87 (42.6) |
| Spastic diplegia | 101 (22.3) | 16 (15.8) |
| Spastic hemiplegia | 44 (9.7) | 29 (65.9) |
| Dystonic | 46 (10.2) | 12 (26.1) |
| Hypotonic | 23 (5.1) | 8 (34.8) |
| Ataxic | 2 (0.4) | 0 (0) |
| Mixed | 32 (7.1) | 8 (25.0) |
| Total | 452 (100) | 160 (35.4) |

palsy who were receiving rehabilitation services and were already on follow-up at Prayas. There was no overlap between the two groups. All of these children were outpatients only.

Cerebral palsy was classified as spastic quadriplegia (equal spasticity of all four limbs), spastic hemiplegia (unilateral spasticity), spastic diplegia (spasticity of all four limbs with lower limbs more involved than upper limbs), dyskinetic (dystonia, choreiform, or athetoid movements with or without some degree of rigidity), ataxic (ataxia not attributable to weakness, spasticity, dystonia, or choreoathetosis), and mixed cerebral palsy (a combination of the previous categories). Epilepsy was defined as two or more unprovoked seizures. Children were assigned to the respective subtype of epilepsy or epileptic syndrome based on the International League Against Epilepsy classifications.[7–9] A detailed history was obtained and a complete clinical examination, including neurodevelopmental assessment, was performed. All of these details were recorded on a prestructured proforma. Computed tomography (CT) and interictal electroencephalography (EEG) were done in all cases. CT and EEG were reported by a neuroradiologist and a pediatric neurologist, respectively. The social quotient was assessed with the help of a clinical psychologist using the Indian adaptation of the Vineland Social Maturity Scale.[10] To maintain objectivity and uniformity of measurement across the entire age range of children, the Vineland Social Maturity Scale was used for measuring the social quotient. Being a parental interview, it is also not dependent on patient compliance, which is often difficult in young children with cerebral palsy. Moreover, there are several problems with using the Wechsler Intelligence Scale for Children (WISC) in children with cerebral palsy because of their associated physical and sensory defects. Hence, we used the social quotient as an alternative objective measure. The results were interpreted as social quotient normal, > 90; social quotient low-average/borderline, 71 to 90; mild mental retardation, IQ 55 to 70; moderate and severe mental retardation IQ, < 55. Sixty children with cerebral palsy but no epilepsy matched for age and type of cerebral palsy were studied for comparison of the social quotient to see if there was any difference between the two groups. These were selected from children with cerebral palsy coming to the center for rehabilitation who had never had seizures.

Data were expressed using descriptive statistics. Comparison between different subgroups of cerebral palsy and subgroups of epilepsy was done using the chi-square test. Quantitative variables were analyzed by Student's *t*-test. Also, comparison between the variables of subtypes of cerebral palsy, subtypes of epilepsy, social quotient values, requirement of polytherapy, and CT findings was done using biserial correlation analysis. The relationship between social quotient and other variables was determined by multiple regression analysis.

## RESULTS

### Prevalence of Epilepsy in Cerebral Palsy

Of the 452 children with cerebral palsy in group B, 160 (35.4%) were found to have epilepsy. Details of the type of cerebral palsy and prevalence of epilepsy in these children are shown in Table 1. Children with hemiplegia had the maximum prevalence of epilepsy (65.9%), whereas those with diplegia had the least (15.8%), and 42.6% children with quadriplegia had epilepsy.

Of the 105 children in group A, 40 were female. Their age ranged from 1 to 12.5 years (mean 51 months). A history of birth asphyxia (delayed cry > 5 minutes after birth) was obtained in 40 (38%). Neonatal jaundice requiring intervention (exchange/phototherapy) was reported in 9 (8.5%) and a history of neonatal seizures in 12 (11.4%) children.

### Age of Onset of Seizures

The mean age of onset of seizures was 18.9 months. Most patients had seizure onset around 8 months; 64 (60.95%) children had their first seizure before 1 year of age and 19 (15.2%) and 13 (12.3%) children after 1 and 2 years, respectively. Only 7 (6.7%) children experienced their first seizure after 4 years of age. It was seen that patients with myoclonic jerks and infantile spasms had seizures beginning significantly early in life, that is, within the first year ($P < .05$ and $P < .01$, respectively). Children with generalized tonic-clonic seizures and those with hemiplegia had significantly late seizure onset ($P < .05$). The earlier the onset of seizures, the higher was the frequency of seizures ($P < .01$). The mean age of seizure onset was earlier in children with quadriplegia and diplegia (17.1 and 16.9 months) compared with children with hemiplegia (29.7 months).

### Types of Seizures in Different Types of Cerebral Palsy

Seizure types in different types of cerebral palsy are shown in Table 2. Overall, there was virtually equal distribution of generalized tonic-clonic, partial, and myoclonic seizures. Generalized seizures were the most common in spastic quadriplegia and diplegia, whereas partial seizures were the most common in children with hemiplegia. Some children had multiple seizure types. Occasional astatic seizures were reported in two children, along with myoclonic seizures. Typical or atypical absence seizures were not reported in any child.

### Seizure Control and Withdrawal of Antiepilepsy Drugs

Seizures could be controlled in 58.1% of the children. Antiepilepsy drugs could be withdrawn in only 6 children (5.7%). Whereas seizure control was achieved in 75% of the cases of hemiplegia, the same was possible in only half of the children with quadriplegia and diplegia.

**Table 2. Seizure Type in Subtypes of Cerebral Palsy**

| *Seizure Type* | *SPQ (n = 53)* | *SPD (n = 20)* | *SPH (n = 22)* | *DYS (n = 5)* | *HYPO (n = 3)* | *Mixed (n = 2)* | *Overall (n = 105)* |
|---|---|---|---|---|---|---|---|
| GTC | 19 (35.1%) | 9 (45%) | 7 (31.8%) | 1 (20%) | 3 (100%) | 1 (50%) | 40 (38.1%) |
| SP | 3 (5.7%) | 3 (15%) | 1 (4.5%) | 1 (20%) | 0 | 1 (50%) | 9 (8.6%) |
| CP | 6 (11.3%) | 1 (5%) | 6 (27.3%) | 0 | 0 | 0 | 13 (12.4%) |
| P-SG | 7 (13.2%) | 3 (15%) | 3 (13.6%) | 0 | 0 | 0 | 13 (12.4%) |
| MJ | 9 (17%) | 3 (15%) | 1 (4.5%) | 2 (40%) | 0 | 0 | 15 (14.3%) |
| IS | 14 (26.4%) | 5 (25%) | 3 (13.6%) | 1 (20%) | 0 | 0 | 23 (22%) |
| Others | 0 | 1 (5%) | 0 | 0 | 0 | 0 | 1 (1%) |

CP = complex partial; DYS = dyskinetic; GTC = generalized tonic clonic; HYPO = hypotonic; IS = infantile spasms; MJ = myoclonic jerks; P-SG = partial with secondary generalization; SP = simple partial; SPD = spastic diplegia; SPH = spastic hemiplegia; SPQ = spastic quadriplegia.

**Polytherapy Requirements**

Polytherapy was required in 40 (38.1%) patients, with 28 (26.6%) requiring two drugs and 12 (11.5%) requiring three drugs. Polytherapy was required in 50% of the children with diplegia, 35.2% of the children with quadriplegia, and 25% of the children with hemiplegia. Comparison of various parameters in the groups of children requiring polytherapy versus monotherapy is depicted in Table 3. There was no significant difference in any of the parameters except the type of seizure. Polytherapy was most often required in cases with infantile spasms (58.3%) ($P < .05$), followed by other types of myoclonic epilepsy (46.7%) and partial (46%) and generalized seizures (30%). Children on polytherapy had increased frequency ($P < .05$) and poor control ($P < .01$) of seizures.

**CT Findings**

Abnormal CT findings were found in 64 (61%) children, of whom 48 (73.8%) had bilateral and 17 (26.2%) had focal findings. CT abnormality was most common in hemiplegia and diplegia (75% each), followed by quadriplegia (57.4%). CT abnormalities in hemiplegia were unilateral in 60% of the cases, whereas 93% of the children with diplegia and 83.9% with quadriplegia showed bilateral abnormalities.

Cerebral atrophy was the most common finding, followed by infarcts. Periventricular leukomalacia was the most common finding in diplegia, along with atrophy and hypoxic changes. Porencephalic cyst, infarct, and atrophy were equally common in hemiplegia; each of these was seen in four children. Both patients with hypotonic cerebral palsy had evidence of cerebral atrophy.

**Electroencephalography**

The EEG was abnormal in 74 children (70.5%) (Table 4). The abnormality was generalized in 44, focal in 13, and focal with secondary bilateral synchrony in 17 children. Slowing of rhythm and asymmetry was noted in 13 and 3 patients, respectively. Slowing was most often seen in children with quadriplegia and hemiplegia. Most of the children with quadriplegia and diplegia showed generalized abnormality. Seven of 16 children with hemiplegia and abnormal EEG had focal activity.

**Social Quotient**

The mean social quotient of the 105 children was 45.1. The majority (60%) of the children were moderately to severely retarded. A low social quotient was seen in most of the children with quadriplegia (73.2%) and hemiplegia (75%), as well as in children with hypotonic and mixed cerebral palsy. A normal to borderline social quotient was seen in 45% of the cases of diplegia and 60% of the cases of dystonic cerebral palsy. However, no significant difference in social quotient was found between the two matched groups of patients with cerebral palsy and seizures (social quotient 47.3%) versus cerebral palsy without seizures (social quotient 48%).

Social quotient values were found to have a positive correlation with age of onset of seizures, that is, the higher the age of onset of seizures, the higher the social quotient ($P < .01$). Most patients with severe mental retardation (77.8%) had their first seizure before their first birthday. This percentage decreased to 43.8 in those with a borderline social quotient and 9.1% in those with a normal social quotient. Social quotient values also had a positive correlation with better control of seizures ($P < .01$). Control of seizures could be achieved in the majority (74%) of patients with a normal to borderline social quotient but in only 48.7% of patients with mental retardation. Nearly 53% of patients with mental retardation had daily seizures, whereas only 18.5% of the patients with normal to borderline intelligence had daily seizures. With increasing severity of mental retardation, seizures were more severe. Among those with mild mental retardation, only 26.7% had daily seizures, and in 60%, seizures could be controlled. In moderate to severe mental retardation, more than half had daily seizures, and in only 49.2% could they be controlled. Lower social quotient values had a significant correlation with occurrence of birth asphyxia ( $P < .05$), microcephaly ($P < .01$), and frequency of seizures ($P < .01$). Also, patients with quadriplegia had a significantly lower social quotient than other groups ($P < .05$).

## DISCUSSION

This study included consecutive children with cerebral palsy and epilepsy without any selection bias as children

**Table 3. Comparison of Children on Polytherapy and Monotherapy**

| *Characteristics* | *Polytherapy (n = 40) (%)* | *Monotherapy (n = 65) (%)* |
|---|---|---|
| Mean age (mo) | 51.1 | 51.13 |
| History of birth asphyxia | 13 (32%) | 27 (41.5%) |
| Neonatal seizures | 6 (15%) | 6 (9%) |
| Seizure onset (mean) (mo) | 17.9 | 19.5 |
| Microcephaly | 30 (75%) | 47 (72%) |
| CT abnormalities | 26 (65%) | 38 (58.5%) |
| Unilateral | 10 (25%) | 17 (26.2%) |
| EEG abnormalities | 31 (77.5%) | 43 (66.2%) |
| Bilateral | 31 (77.5%) | 36 (55.4%) |
| Mean SQ | 41.4 | 47.4 |
| Mental retardation | 32 (80%) | 46 (71%) |

P = not significant for all.
CT = computed tomography; EEG = electroencephalogram; SQ = social quotient.

were brought to the rehabilitation center primarily for management of cerebral palsy and not for primary management of seizures. We feel that the sample is reasonably representative, although some milder cases of cerebral palsy and epilepsy that may not have been brought to the rehabilitation center/hospital may have been left out. Occasional cases of cerebral palsy that could have presented as status epilepticus or severe seizures requiring hospitalization were not included in this study as only children with cerebral palsy brought as outpatients were included.

The distribution of various types of cerebral palsy is similar to our previous studies[5,11] and those by others from India.[6] The incidence of epilepsy in cerebral palsy has been variably reported from 33 to 41.2%.[5,12,13] In this study, about one third of children with cerebral palsy had epilepsy. This is generally the experience of others.[13,14] The incidence and type of epilepsy vary according to the type of cerebral palsy. We found epilepsy to be most common in hemiplegia (65.9%) and in quadriplegia (42.6%), which is perhaps related to the cortical involvement and severity of brain damage in these cases. Epilepsy was least common in diplegia (15.8%), possibly because the brain damage in these cases is mostly periventricular. Hadjipanayis et al reported epilepsy in almost half of their patients with quadriplegia and hemiplegia.[12] Others have reported figures of 54% in quadriplegia, 34 to 60% in hemiplegia, 27% in diplegia, and 23 to 26% in dystonic cerebral palsy.[2–4,15,16] The incidence of seizures in children with hypotonic cerebral palsy was lower in our study compared with others, who have reported an incidence of 87.5%.[13] The small number of hypotonic patients in our study may have accounted for this difference.

Generalized seizures were the most common, followed by partial seizures. About one fourth had infantile spasms and 14.3% had myoclonic jerks. These figures closely match those of Hadjipanayis et al, who reported generalized seizures in 36.8%, partial seizures in 33%, West's syndrome in 15.6%, and myoclonic jerks in 10.6%.[12] No case of absence seizures was found in our study. Other researchers have reported absence seizures in 3.3 to 6.7%.[13] However, of the six patients with absence seizures seen by Hadjipanayis et al, only one had typical absences; all others had atypical absence seizures.[12] Seizure types seem to be poorly related to the neurologic findings.[17]

Most children with cerebral palsy had seizure onset within the first (61%) or second year of life. Other researchers reported 36.7%[18] and 69.7%[13] of patients with seizure onset in the first year of life. The onset of epilepsy probably reflects the time of occurrence of brain damage and its severity. The earlier onset of seizures in our study may possibly be related to the severity of cerebral palsy in our study.

The age of seizure onset is also related to the type of cerebral palsy. Like Hadjipanayis et al,[12] we also found a significantly earlier age of onset of seizures in children with quadriplegia and diplegia compared with children with hemiplegia. Whereas over 60% of the children with quadriplegia and diplegia had seizures beginning in their first year, 60% of the children with hemiplegia had their first seizure after their first birthday.

Seizure control in children with cerebral palsy is difficult and could be achieved in just over half of the patients. Whereas seizures in children with quadriplegia and diplegia could be controlled in about 50%, they were controlled

**Table 4. EEG Abnormality and Type of Cerebral Palsy**

| *EEG* | *SPQ (n = 53)* | *SPD (n = 20)* | *SPH (n = 22)* | *DYS (n = 5)* | *HYPO (n = 3)* | *Mixed (n = 2)* | *Total (n = 105)* |
|---|---|---|---|---|---|---|---|
| Generalized activity | 21 | 10 | 9 | 2 | 2 | 0 | 44 |
| Focal activity | 5 | 2 | 4 | 2 | 0 | 0 | 13 |
| Focal onset—bilateral synchrony | 10 | 3 | 3 | 0 | 0 | 1 | 7 |
| Total | 36 (67.9%) | 15 (75%) | 16 (72.7%) | 4 (80%) | 2 (66.6%) | 1 (50%) | 74 (70.5%) |

DYS = dyskinetic; HYPO = hypotonic; SPD = spastic diplegia; SPH = spastic hemiplegia; SPQ = spastic quadriplegia.

in 75% of children with hemiplegia. Seizure control has been reported in nearly two thirds by others.[13] This probably reflects the increased severity of seizures and cerebral palsy in our children. Also, most of our 105 children had active epilepsy throughout the study period. It has been recognized that children with cerebral palsy have low seizure remission rates of about 12.9 to 14% and high relapse rates of 41.5 to 62.5%.[18,19]

Seizure control was achieved with monotherapy in the majority of cases. Polytherapy was required in half, one third, and one fourth of cases with diplegia, quadriplegia, and hemiplegia, respectively, although this difference was not significant. This is slightly different from the study by Hadjipanayis et al, wherein children with spastic hemiplegia (35%) and tetraplegia (28%) were more likely to require polytherapy compared with patients with spastic diplegia (11%); however, the differences were not significant.[12] The requirement of polytherapy did not correlate significantly with any patient characteristics. As expected, it was required more often in children with infantile spasms and myoclonic seizures. All other seizure characteristics also were more severe in the group requiring polytherapy. Seizures began earlier, and CT and EEG abnormalities were more often present in children requiring polytherapy, although these values did not reach statistical significance.

EEG abnormality was commonly seen in children with cerebral palsy and epilepsy (66%). All of the subgroups of spastic cerebral palsy had a greater than 70% incidence of abnormal EEGs. Whereas patients with quadriplegia and diplegia showed predominant bilateral epileptic activity, about half of children with hemiplegia had focal findings. In a study of children with cerebral palsy and epilepsy, not further defined, only 7.9% of children had normal interictal EEGs.[13]

CT abnormality is common, particularly in patients with spastic cerebral palsy. Cerebral atrophy was the predominant finding in quadriplegia, whereas infarction, porencephalic cyst, and cerebral atrophy occurred equally (26.7%) in hemiplegia. As anticipated, periventricular leukomalacia was significantly ($P < .05$) more common in diplegia. Pedersen et al reported CT abnormality in 77% of the cases of hemiplegia, followed by quadriplegia (75%) and diplegia (55%).[20] In another study, CT abnormalities were found in 77.2% of patients, with bilateral atrophy in 42.1% and focal findings in 17.6% of the cases.[18]

Correlation was noted between CT and EEG findings. Children with bilateral abnormality on CT generally had EEGs with generalized epileptic activity, although in one fourth, a focal onset with secondary bilateral synchrony was seen. Children with unilateral CT abnormalities had 35.3% of EEGs with focal onset of seizure activity. The focality on the EEG was on the same side as the CT lesion in all cases.

The majority of the children in our study had some degree of mental retardation. Only 5% and 15% had normal and borderline social quotients, respectively. Mental retardation was most common in children with quadriplegia, followed by hemiplegia. On the contrary, almost half of children with diplegia and 60% of children with dystonic cerebral palsy had normal to borderline intelligence, which again correlates well with the type and location of brain damage. An interesting finding of this study is the association of mental retardation with earlier age of onset, increased frequency, and difficult to control seizures. This has also been observed by others.[21] It is possible that this represents an underlying severity of brain injury that is responsible for both the severity of cognitive deficit as well as that of epilepsy. Uvebrandt and Aicardi et al have shown that the presence of mental retardation in a child with cerebral palsy is associated with a higher possibility of developing seizures.[3,15] On the whole, children with both cerebral palsy and epilepsy have lower intelligence than those with no recognized seizures.[17] The adverse effects of additional epilepsy on intelligence, memory, and learning have been reported in hemiplegic cerebral palsy.[22] In this study, however, we did not find a significant difference in IQ of children with cerebral palsy and epilepsy versus a comparison group of children with cerebral palsy without epilepsy. Perhaps the numbers studied may not have been enough.

To conclude, seizures occur in about one third of children with cerebral palsy. Generally, the onset is within the first 2 years of life. Seizures are most often seen in spastic hemiplegia and quadriplegia. Generalized seizures are the most common, followed by partial seizures; infantile spasms and myoclonic jerks are seen in about one fourth of cases. Often the seizures are difficult to control, and polytherapy is required in one third to half of the cases. Children with mental retardation have an early onset of seizures and more severe epilepsy. These factors need to be considered when planning intervention services for children with cerebral palsy.

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# *Correction*

**Childhood-Onset Chronic Inflammatory Demyelinating Polyradiculoneuropathy With Cranial Nerve Involvement**

In *Journal of Child Neurology* Volume 17, Number 11, November 2002 “Childhood-Onset Chronic Inflammatory Demyelinating Polyradiculoneuropathy With Cranial Nerve Involvement” page 821, a sentence was published incorrectly.[1] On page 821, left-hand column, line 19 the word “not” is missing in the sentence and should have read:

The patient did not meet diagnostic criteria for systemic lupus erythematosus.

***Reference***

1. Costello F, Lee AG, Afifi AK, et al: Childhood-onset chronic inflammatory demyelinating polyradiculoneuropathy with cranial nerve involvement. *J Child Neurol* 2002;17:819–823.