Seizures in Children With Cerebral Palsy and White Matter Injury

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abstract

OBJECTIVE: The goal of this study was to describe the prevalence, syndromes, and evolution of seizure disorders in children with cerebral palsy (CP) due to white matter injury (WMI).

METHODS: For this population-based cohort study, brain MRI scans and medical records were reviewed in children in the Victorian Cerebral Palsy Register born between 1999 and 2006 recorded as having WMI. Children were excluded if they had features of an undiagnosed syndrome, associated cortical malformation or injury, or no medical contact in the preceding year. Included were 166 children with CP and isolated WMI due to presumed vascular insufficiency or hemorrhage; 87 were born preterm. Seizure and CP details were obtained from medical records and interviews, and EEG recordings were reviewed.

RESULTS: Forty-one children (25%) had seizures beyond the neonatal period. Four children had West syndrome, which resolved with treatment. Thirteen children had febrile seizures that they outgrew. Thirty children had focal epilepsy with seizure manifestations and EEG discharges typical of early-onset childhood occipital epilepsy or childhood epilepsy with centrotemporal spikes; 23 have outgrown these seizures. Two children had idiopathic generalized epilepsy; it was ongoing in 1 child. Fourteen children had evolution from 1 epileptic syndrome to another. At last follow-up (median age, 12.7 years; minimum age, 9.7 years), 80% had not had a seizure for >2 years.

CONCLUSIONS: The electroclinical features of seizure disorders associated with CP and WMI are those of the age-limited, epileptic syndromes of childhood, with favorable outcome in the majority. The findings have important implications for counseling and drug treatment.

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Dr Cooper designed the data collection instruments, coordinated and supervised data collection at 2 sites, conceptualized and designed the study, and drafted the initial manuscript. Drs Mackay and Harvey conceptualized, supervised data collection, designed the study, and drafted the initial manuscript; Dr Mackay reviewed all available MRIs, and Dr Harvey reviewed all available EEGs. Drs Reddihough, Reid, and Williams conceptualized and designed the study and critically reviewed the manuscript; and Dr Fahey critically reviewed the manuscript and supervised data collection at 1 site. All authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Seizures occur more frequently in children with cerebral palsy (CP) than in typically developing children. Few studies address the heterogeneity of epilepsies in CP. Seizures are often attributed to the underlying brain abnormality, with expected poor prognosis for seizure remission.

WHAT THIS STUDY ADDS: One in 5 children with CP due to white matter injury develops seizures. Seizures occur in the context of age-limited, epileptic syndromes of childhood, with a favorable outcome in the majority. This has implications for counseling and antiepileptic drug treatment.

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Cerebral palsy (CP), a group of nonprogressive disorders of movement and posture, occurs in ~2 per 1000 live births.[1] The pathologic substrates and etiologies of CP are varied, the most common being white matter injury (WMI) complicating cerebral ischemia or hemorrhage in preterm and term infants.[2] Reported rates of seizures and epilepsy in CP vary widely depending on patient ascertainment, underlying pathology, and etiology.[3–7] Studies of epilepsy in CP should ideally be population based, address specific CP subtypes and etiologies, and analyze electroclinical features beyond just the presence of seizures. However, few studies address the heterogeneity of epilepsy in children with CP, overlooking important aspects of seizure semiology and specific EEG patterns.[8–11] In children with CP, the presumption is that they have a "structural" or "symptomatic" epilepsy, the seizures will likely continue into later life, and the childhood epileptic syndromes are not relevant.[12]

We previously described the epileptology of hemiplegic CP secondary to perinatal arterial ischemic stroke, noting that the majority of children had common epileptic syndromes with favorable outcome.[13] The present article describes the epileptic syndromes associated with CP and WMI due to presumed cerebral ischemia or hemorrhage.

METHODS

The Victorian Cerebral Palsy Register, which was established in 1986,[14,15] was searched for children with prenatally or perinatally acquired CP born between 1999 and 2006 who had an MRI after age 6 months and were classified as having "WMI."[16] MRIs were reviewed by a pediatric neurologist (MTM in all cases and ASH in cases of uncertainty), blinded to the children's history and gestation, to confirm and characterize the WMI and to exclude those with associated cortical involvement, such as focal encephalomalacia, cortical gliosis, or hippocampal sclerosis.

Medical records from the 2 pediatric hospitals in Victoria were screened for information about the children's CP and its etiology. Children were excluded if pathologic copy number variants or underlying genetic syndromes were identified; conditions such as autosomal recessive primary microcephaly, Wolf-Hirschhorn syndrome, or Waardenburg syndrome were identified.

Information about potential seizures was obtained from medical records. In addition, parents/guardians were invited by mail to participate in a telephone interview to determine whether their child ever had an epileptic seizure. Children were excluded if their parents or carers could not be interviewed and their medical record contained no clinical information during the previous 12 months because the presence of seizures and the current status of any seizures could therefore not be reliably determined.

Information was obtained about family history of seizures, age and circumstances of seizures, seizure descriptions, seizure outcome, treatment details, Gross Motor Function Classification System[17] level, and the presence of intellectual disability and behavioral problems. EEG recordings were reviewed by a pediatric neurologist (ASH) for the presence of interictal epileptiform discharges (IEDs); 3 of the total 79 EEG recordings were not available, and the reports were used.

Epilepsy was defined as ≥2 afebrile seizures occurring beyond the neonatal period.[18] Epileptic syndrome diagnoses were made in accordance with the International League Against Epilepsy classification scheme.[19]

Data were analyzed by using Stata version 14.1 (StataCorp, College Station, TX). The strength of associations between seizure status and categorical variables (demographic, clinical, EEG, and imaging data) were tested by using χ^2 or Fisher's exact tests, and numerical data were compared by using a Mann-Whitney *U* test. A Kaplan-Meier plot was produced for time from onset of epilepsy until 2 years after the last seizure.

The study was approved by the Human Research and Ethics Committees of the Royal Children's Hospital and Monash Children's Hospital, Melbourne.

RESULTS

Search of the Victorian Cerebral Palsy Register returned data on 256 children with a categorization of "WMI." Review of MRIs excluded 53 children with associated cortical abnormalities or WMI suggestive of a genetic syndrome. Screening of medical records excluded 23 children with genetic or syndromic diagnoses. Fourteen children were excluded because clinical information for the preceding 12 months was unavailable, including 2 deceased children (Fig 1). Three of these children had a history of seizures or possible seizures; 1 child had West syndrome followed by a tonic-clonic seizure, 1 child had a focal seizure, and 1 child died with minimal information available about the reported episodes.

A total of 166 children with CP and isolated WMI were included in the study; their perinatal, CP, and MRI findings are summarized in Table 1. Eighty-seven children were born preterm (<37 weeks). Eighty-seven families were interviewed by telephone, and information about possible seizures was gleaned from medical records in the remainder. The median age at last telephone or hospital contact was 13.7 years. Of

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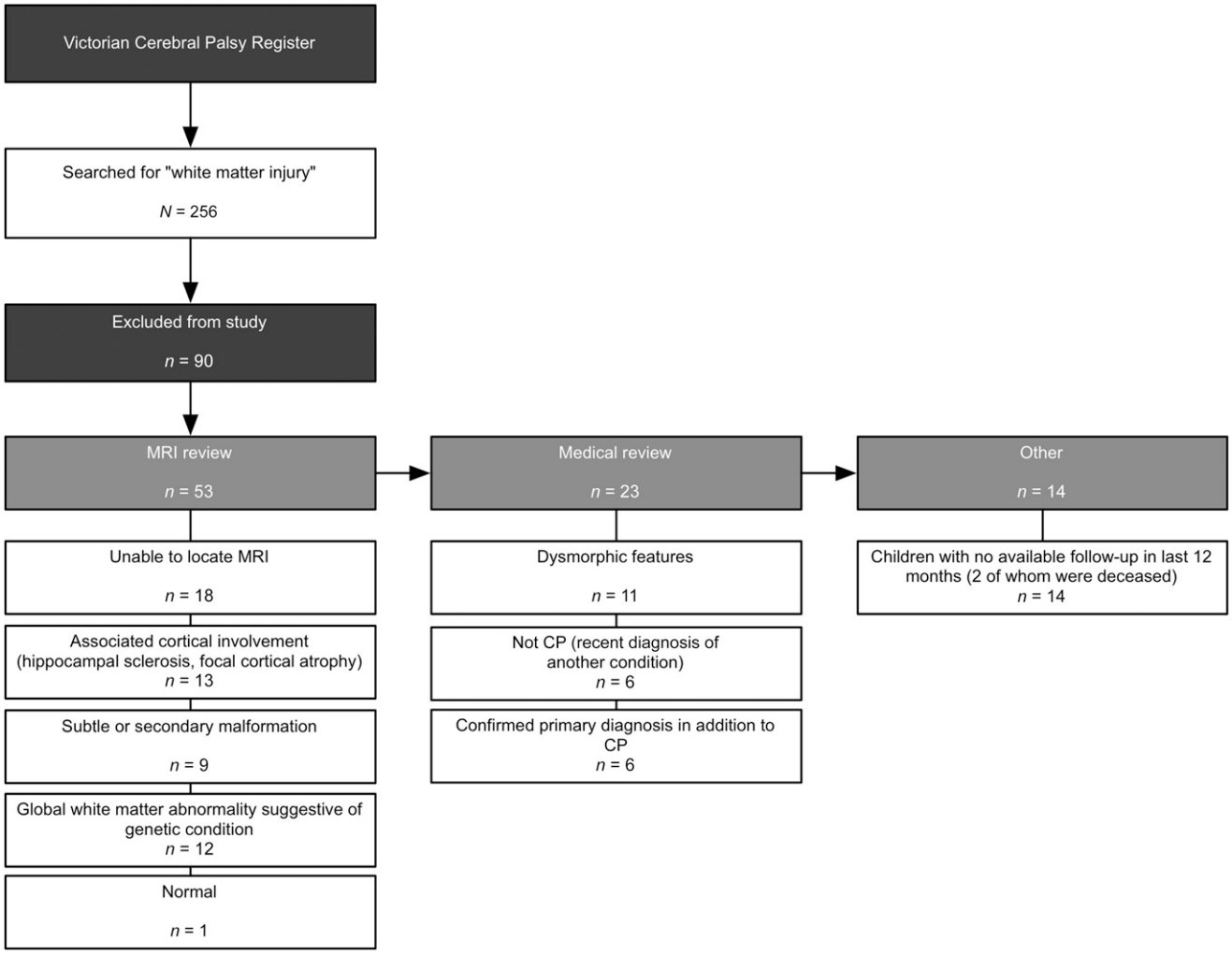

FIGURE 1

Diagram showing the exclusion of children identified by search of the Victorian Cerebral Palsy Register for "birth 1999–2006" and "white matter injury." Subsequent review of patients' MRI scans and medical records yielded 166 children with isolated WMI due to presumed vascular insufficiency or hemorrhage in whom medical or study contact was documented in the preceding 12 months.

these 166 children, 41 (25%) had at least 1 epileptic seizure beyond the neonatal period. Thirteen children presented with febrile seizures, 4 of whom went on to develop afebrile seizures. Twenty-eight children presented with afebrile seizures and were single seizures in 7. The frequency of epilepsy was 15% (25 of 166).

Clinical seizure characteristics, EEG findings, antiepileptic drug (AED) treatment, and seizure outcome are summarized in Table 2 and are presented as epileptic syndromes in order of typical appearance during childhood. Five years after seizure onset, 51% (21 of 41) of children who had had at least 1 seizure had not had a seizure for >2 years (Fig 2). At the end of the study, 80% (33 of 41) of the children had not had a seizure for >2 years.

West Syndrome

Four infants (2.4%) developed epileptic spasms at a median age of 5.5 months (interquartile range [IQR], 5–6 months), with epileptic spasms being the presenting seizures in 3. None of the infants had a family history of seizures. Patients 1, 2, and 3 were born preterm, and patient 4 was born at term. Patient 1 had preceding left focal motor seizures with right hemisphere slowing and right frontal IEDs on EEG before developing left-sided flexor spasms with bilateral hypsarrhythmia on EEG, more prominent on the right. Patients 2 and 3 had subtle focal features during epileptic spasms, 1 having slight head turning to the left and the other eye deviation to the left; both had bilateral, asynchronous hypsarrhythmia on EEG. Regression was not apparent in the 3 preterm infants. Patient 4 had spasms manifesting as head nodding, with right-sided hypsarrhythmia on EEG. Developmental regression occurred with evolution of left-sided spasticity leading to the diagnosis of CP.

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TABLE 1 Demographic, CP, and MRI Features of Children With and Without Seizures

Characteristic	Total (N = 166)	With Seizures (n = 41)	Without Seizures (n = 125)
Demographic			
Sex: male	100 (60%)	29 (71%)	71 (57%)
Age at study, median (IQR), y	12.7 (10.7–14.9)	13.7 (11.6–15.3)	12.3 (10.6–14.2)
Gestation, median (IQR), wk	35 (30–39)	35 (30–40)	36 (30–39)
Birth weight,[a] median (IQR), g	2329 (1470–3390)	2065 (1350–3090)	2520 (1475–3420)
Neonatal seizures[b]	12 (7%)	4 (10%)	8 (6%)
CP subtypes[c]			
Monoplegia	2 (1%)	0	2 (1%)
Diplegia	70 (42%)	17 (41%)	53 (42%)
Triplegia	12 (7%)	4 (10%)	8 (6%)
Hemiplegia	70 (42%)	16 (39%)	54 (43%)
Quadriplegia	9 (5%)	4 (10%)	5 (4%)
Gross Motor Function Classification System[d]			
Level I	86 (52%)	17 (41%)	69 (55%)
Level II	44 (27%)	13 (32%)	31 (26%)
Level III	18 (11%)	4 (10%)	14 (11%)
Level IV	12 (7%)	5 (12%)	7 (6%)
Level V	3 (2%)	2 (5%)	1 (1%)
MRI			
Bilateral white matter injury	146 (88%)	35 (85%)	111 (89%)
Porencephalic cyst*	6 (4%)	5 (12%)	1 (1%)
Ventriculoperitoneal shunt**	4 (2%)	2 (5%)	2 (2%)

Missing data: [a]n = 14, [b]n = 9, [c]n = 3, [d]n = 3.

* P = .004 (Fisher's exact test) for association between porencephalic cyst and seizures.

** P = .26 (Fisher's exact test) for association between ventriculoperitoneal shunt and seizures.

All infants were treated with vigabatrin, and 1 received prednisolone. Spasms ceased in all infants. EEGs during the following year in 3 infants showed resolution of hypsarrhythmia. Patients 1, 2, and 3 subsequently developed focal seizures with centrotemporal spikes (CTS) or occipital spikes (OS) at age 4 years, 19 months, and 3 years, respectively. Patient 4 had no further clinical seizures, but follow-up EEGs revealed CTS and OS.

Febrile Seizures

Thirteen children (8%) developed febrile seizures at a median age of 1.5 years (IQR, 0.6–4 years) and were the presenting seizures in 12 children. Patient 9 had prior neonatal seizures. There was a family history of febrile seizures in 4 children. Seven children were born preterm. Febrile seizures were generalized and brief in the majority, and occurred only once in 6 children. EEGs in 5 children during the period of febrile seizures did not show IEDs.

Four children were treated with AEDs. No further febrile seizures occurred after age 6 years in 11 children. Febrile seizures continued until age 6.8 years in patient 13 and 7.5 years in patient 8, the latter patient having had 2 EEGs not showing IEDs.

Idiopathic Generalized Epilepsy

Two children (1.2%) developed idiopathic generalized epilepsy. Neither had a history of neonatal or febrile seizures.

Patient 38 was born at 30 weeks' gestation. He had a family history of febrile seizures in second-degree relatives. At 9 years of age, he presented with myoclonic and generalized convulsive seizures while taking gabapentin for pain. He had generalized spike-wave (GSW) and OS on EEG. Gabapentin was changed to sodium valproate.

Patient 40 was born at term and had a family history of epilepsy in a second-degree relative. He presented at age 3 years with typical childhood absence seizures associated with 3 Hz GSW on EEG, which remitted by age 5 years after treatment with sodium valproate and clobazam. He later developed focal seizures with CTS but no GSW on EEG.

Focal Epilepsies

Focal seizures developed in 30 children (18%) after infancy, at a median age of 6.0 years (IQR, 2.9–8.8 years) and were the initial seizures in 22 children. A family history of seizures in first-degree relatives was present in 4 children (febrile seizures in 2 and epilepsy in 2). Fifteen children were born preterm. Eight children had a history of prior seizures: West syndrome in 3, febrile seizures in 4, and absence seizures in 1.

Reported seizure duration was >10 minutes in 20 children. Seizures occurred from sleep in 20 (67%) children. Consciousness was definitely preserved in 17 children. Autonomic symptoms occurred in 28 children, vomiting in 14, and hypersalivation in 17. Nineteen children had hemifacial motor manifestations, 11 had speech arrest, and 23 had altered oral sensation and

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TABLE 2 Clinical, EEG, and Treatment Details of 41 Children With CP, WMI, and Seizures

Patient No./Sex	Age at Seizure Onset, y	Seizure Types	Total No. of Seizures	EEG Epileptiform Findings	Epileptic Syndrome(s)	Medications	Age at Last Seizure/Follow-up, y
1/M	0.1	ES, Fc	2[a,b]	Hyp → OS + CTS → none	WS → EOCOE → CECTS	PB → VGB → CBZ + CZP → VPA → none	4/11[c]
2/M	0.3	ES, Fc	35[a,b]	Hyp→ CTS	WS → CECTS	VGB + PNL → VPA + LTG	9/11[c]
3/M	0.4	ES, Fc	120[a,b]	Hyp → CTS	WS → CECTS	VGB → LEV → LTG → VPA + CLB → LTG + LEV	11/13[c]
4/M	0.4	ES	0[a]	Hyp → OS + CTS	WS	VGB → LEV → none	1/15[c]
5/M	2	Fb	9	None	Fb	VPA → none	3/15[c]
6/F	2	Fb	1[b]	Not done	Fb	PB → VPA	2/15[c]
7/M	0.8	Fb	1	Not done	Fb	None	0.8/14[c]
8/M	3	Fb	7	None	Fb	None	7/14[c]
9/M	3	Fb	3[b]	None	Fb	LTG + VPA	5/12[c]
10/M	0.8	Fb	4	Not done	Fb	None	4/10[c]
11/M	1	Fb	8[b]	None	Fb	VPA → PB → none	5/10[c]
12/F	0.9	Fb	1	None	Fb	None	0.9/9[c]
13/F	4	Fb	2	Not done	Fb	None	6/9[c]
14/F	7	Fc	8[b]	CTS → none	CECTS	VPA → LTG + LEV → LEV	13/16[c]
15/M	8	Fb, Fc	3	CTS	Fb → CECTS	VPA → none	9/16[c]
16/M	5	Fc	25[b]	CTS → none	CECTS → SFE	VPA	16/16
17/M	10	Fc	2	CTS	CECTS	VPA → none	11/16[c]
18/M	1	Fc	1[b]	OS →none	EOCOE	CBZ → none	1/16[c]
19/F	8	Fc	1[b]	None	CECTS	None	8/16[c]
20/M	8	Fc	5[b]	None	EOCOE → CECTS	LEV	15/15
21/M	3	Fc	6[b]	OS	EOCOE + CECTS	None	5/15[c]
22/M	8	Fc	3	OS + CTS	CECTS	None	9/15[c]
23/F	2	Fc	30	None	CECTS	CBZ → none	7/15[c]
24/F	1.5	Fc	3[b]	CTS → none	EOCOE → CECTS	VPA → none	5/15[c]
25/F	3	Fb, Fc	50[b]	CTS	Fb → EOCOE → CECTS	VPA → none	7/15[c]
26/M	2	Fc	1[b]	None	EOCOE + CECTS	CBZ → none	2/14[c]
27/F	8	Fc	1[b]	CTS	CECTS	None	7/14[c]
28/M	10	Fc	3	CTS	CECTS	None	13/14
29/M	7	Fc	40[b]	CTS	EOCOE + CECTS	VPA → CBZ → LEV + CLB → none	12/13
30/F	9	Fc	1	CTS	CECTS	None	9/13[c]
31/F	11	Fc	1	None	CECTS	None	11/13[c]
32/F	3	Fc	1[b]	OS → none	EOCOE	VPA → VPA + LTG → none	3/12[c]
33/M	2	Fb, Fc	4[b]	CTS	Fb → EOCOE → CECTS	CBZ → none	5/12[c]
34/M	4	Fb, Fc	10	CTS	Fb → CECTS	CBZ → none	10/12[c]
35/M	5	Fc	8[b]	CTS	CECTS	VPA → CBZ → LEV → none	8/11[c]
36/M	6	Fc	3	CTS	CECTS	CBZ → VPA	9/10
37/M	6	Fc	6	OS	EOCOE	VPA → OXC → none	6/10[c]
38/M	9	Gn	3[b,d]	GSW + OS	IGE	GBP → VPA → VPA + LEV	10/10
39/M	1	Fc	5[b]	OS	EOCOE	VPA → OXC	6/9[c]
40/M	3	Gn, Fc	25[b]	GSW → CTS	IGE → CECTS	VPA → VPA + CLB	9/9
41/M	9	Fc	3	None	CECTS	None	9/9

CBZ, carbamazepine; CLB, clobazam; CZP, clonazepam; ES, epileptic spasms; F, female; Fb, febrile seizure; Fc, focal seizure; GBP, gabapentin; Gn, generalized seizure; Hyp, hypsarrhythmia; IGE, idiopathic generalized epilepsy; LEV, levetiracetam; LTG, lamotrigine; M, male; OXC, oxcarbazepine; PB, phenobarbitone; PNL, prednisolone; SFE, symptomatic focal epilepsy; VGB, vigabatrin; VPA, sodium valproate; WS, West syndrome.

[a] Not including epileptic spasms.

[b] Prolonged seizures.

[c] No seizure for > 2 years.

[d] Not including myoclonus.

guttural sounds (Supplemental Table 3).

During the period with focal epilepsy, EEGs were performed once in 15 children, twice in 9, three times in 4 children, and four times in 2 children. EEGs showed CTS in 17 children, OS in 5 children, OS and CTS in 2 children, and no IEDs in 6 children. The 6 children with no IEDs had only 1 EEG recorded, and none included sleep. The CTS and OS were stereotyped, sharp-slow discharges that activated when sleep was recorded, often seen with a tangential dipole. Lateralization of IEDs changed on serial EEGs in 3 children. Six children had follow-up EEGs in which IEDs were not seen.

WMI was bilateral in 25 children and unilateral in 5 children. Of the 25 children with bilateral WMI, 8 had bilateral independent IEDs, 8 had unilateral IEDs, 3 had lateralization

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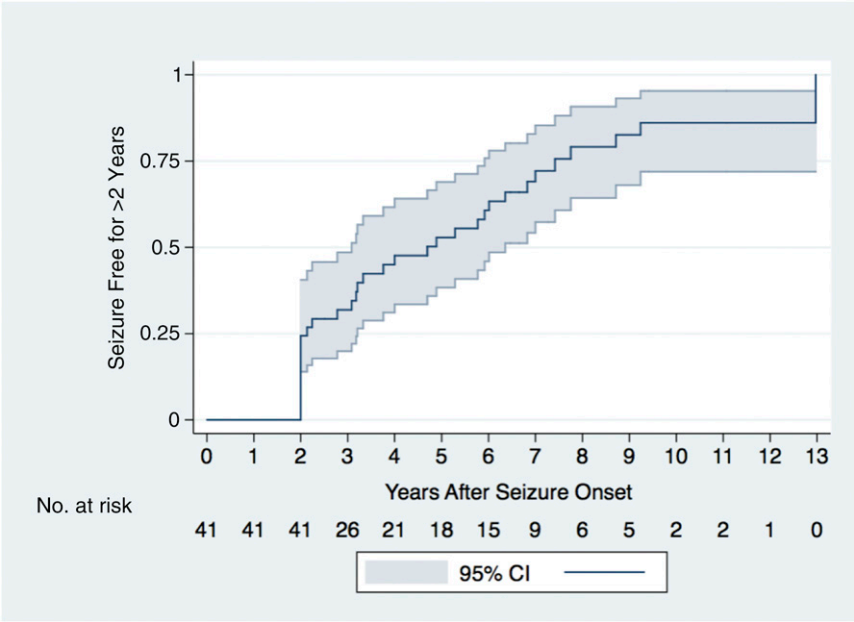

FIGURE 2

Kaplan-Meier plot showing the proportion of children who had not had a seizure for >2 years. Five years after seizure onset, 21 of 41 children had not had a seizure in >2 years (0.47 [confidence interval, 0.24–0.54]). The mean ± SD follow-up after seizure onset was 8.7 ± 3.8 years (range, 0.71–15.4 years).

that changed on serial EEGs, and 6 had no IEDs. Of the 5 children with unilateral WMI, 3 had unilateral CTS on the side of WMI, and 2 had OS arising from the normal hemisphere.

Twenty-two children with focal epilepsy were treated with AEDs. Eleven children were managed with single AEDs and several had changes or additions of AEDs. Carbamazepine worsened seizures in 3 children, necessitating change to another AED. Eight children were not treated because of infrequent seizures or parental choice. AEDs were discontinued in 14 children. Of the 8 children remaining on AEDs, 4 were seizure free during the previous 2 years.

Seventeen children (53%) had <5 focal seizures in total, with 7 children having only a single seizure. Twenty-three children (77%) with focal seizures had not had a seizure for >2 years at the time of last follow-up. Six children (patients 20, 28, 29, 36, 40, and 41) aged 9 to 15 years had focal seizures during the preceding 2 years; 4 children had CTS on their last EEG, and 2 had a normal awake EEG.

Patient 16 with normal intellect had focal seizures between ages 5 and 12 years, with CTS on EEG at age 9 years. Follow-up EEGs at ages 10 and 13 years showed no IEDs, and the patient was weaned off AEDs at age 14 years. At age 15 years, he developed dyscognitive seizures with visual hallucinations, phonophobia, and a tingling sensation on his right side, prompting recommencement of AED treatment.

DISCUSSION

We studied the electroclinical features of seizures in children with the most common pathologic subtype of CP. A population-based CP register was used to identify participants, minimizing ascertainment bias associated with clinical samples, and providing opportunity to compare our findings with other population-based studies. Medical records provided a robust source of information about seizures, as children were often brought to the hospital after seizures, and the ambulance and emergency records had more accurate and contemporaneous seizure details than could be provided later by parents. Many children attended hospital rehabilitation services regularly, enabling us to capture details of children who did not use emergency or inpatient services. Limited clinical information was collected for children without seizures, particularly related to intellectual functioning and family history, as the focus of the study was the epileptic syndromes in children with CP and WMI who had seizures, not risk factors. The exclusion of children with no contact in the previous 12 months, done to maintain surveillance for seizures and allow consistent and extended follow-up of those with seizures, should not have biased our sample, for 2 reasons. First, patients with ongoing or new seizures would be expected to access previous medical services, and second, at least 2 of the 3 excluded patients with seizures had profiles similar to those included in the cohort.

In our study, 25% of children with CP and WMI had seizures, and 15% had epilepsy as classically defined. If we include children who had a single, afebrile seizure and a specific epileptic syndrome diagnosed on clinical and EEG features, the proportion with epilepsy rises to 19% (32 of 166).[19] The frequency of febrile seizures and epilepsy, and the proportion of children with febrile seizures who went on to develop epilepsy, were greater in our study than are reported in the general population.[20] The increased prevalence of seizures in children with CP is well described.[6]

The frequency of epilepsy in CP depends on the etiology. Epilepsy occurs in ~50% to 94% of children with CP due to diffuse cortical

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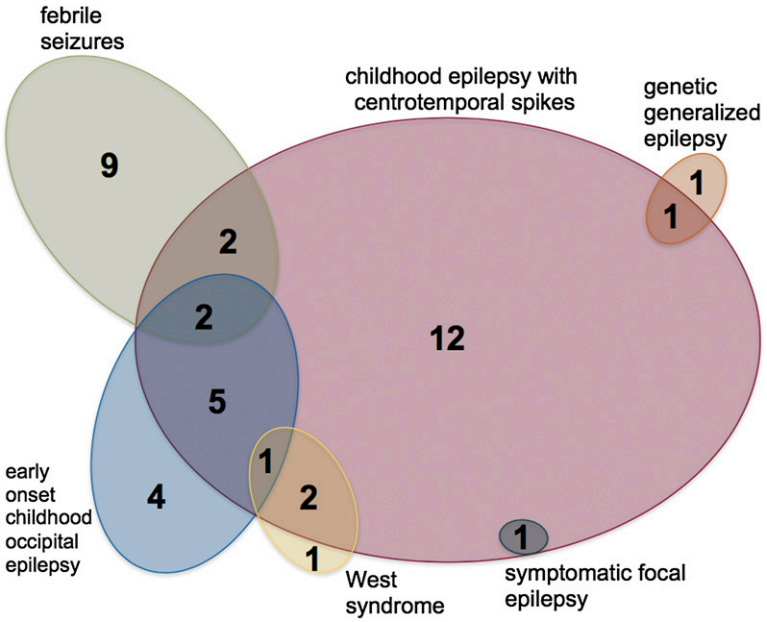

FIGURE 3
Venn diagram showing the epileptic syndromes in 41 children with CP and isolated WMI who had seizures.

malformations and injuries[3,21,22] and in ~50% of children with CP secondary to presumed perinatal arterial ischemic stroke.[13] Epilepsy occurs at a lower frequency (26%–43%),[3–5,7] and with a lower relapse rate after AED discontinuation,[23] in children with CP and WMI than in other etiologies. The frequency of epilepsy in our study was lower than reported in other studies of CP and WMI, likely due to exclusion of children with associated cortical involvement. One might infer that the lower frequency of epilepsy in children with CP and WMI is due to the absence of involvement of cortical gray matter.

When epilepsy is diagnosed in typically developing children, every effort is made to determine an epileptic syndrome diagnosis. An epileptic syndrome encapsulates the age at seizure onset, seizure semiology, interictal and ictal EEG, comorbidities, treatment response, and clinical course, independent of etiology.[18,24] An epileptic syndrome diagnosis informs prognosis and treatment. For example, West syndrome has characteristic ictal phenomenology, EEG findings, and treatment recommendations; however, the underlying etiologies are diverse, and the outcomes for seizure control and development vary.[25] An extension of this concept is that it may not be appropriate for a child with a brain lesion to have his or her epilepsy automatically classified as "structural" or "symptomatic" if the electroclinical features suggest a specific epileptic syndrome. In children with CP, one might assume that seizures are directly related to their underlying cerebral abnormalities and expect poor seizure control. However, in the present study, as well as in our previous study of epilepsy in hemiplegic CP due to arterial ischemic stroke,[13] seizures were often few and well controlled, and in most cases resolved.

Most children in the present study could be diagnosed with common epileptic syndromes of childhood, having typical electroclinical features and outcomes. Of the 4 children with West syndrome, all had resolution of spasms and later focal seizures. Of the 13 children with febrile seizures, one-half had only 1 febrile seizure and all ultimately outgrew their seizures, including the 4 who later developed afebrile focal seizures. All 30 children with focal epilepsy had electroclinical features typical of that seen in the age-limited, usually "benign" focal epilepsies of childhood, specifically the syndromes of early-onset childhood occipital epilepsy (EOCOE) and childhood epilepsy with centrotemporal spikes (CECTS). Four children could be diagnosed with EOCOE, 17 with CECTS, and 8 with overlapping or evolving syndromes (Fig 3). Median onset of EOCOE was 3.2 years, and median onset of CECTS was 6.8 years, similar to the ages of onset in children without CP.[26,27] All had classic focal seizure semiology, with occipital, rolandic, autonomic, or mixed manifestations; the seizures arose from sleep in the majority and were prolonged in many. All children who had EEGs with sleep had classic OS, CTS, or both, changing and remitting on follow-up EEGs in many. Seizure exacerbation with carbamazepine[28] was seen in 3 of 7 treated children. Only patient 16 with focal seizures developed a presumed "symptomatic" focal epilepsy.

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EOCOE, CECTS, and their characteristic EEG patterns are reported in children with a variety of brain abnormalities and developmental disorders.[13,27,29,30] As in the present study, the relationship between laterality of brain injury and IEDs is weak.[31] It is suggested that if all electroclinical features are met in a child with a static brain lesion, diagnosis of benign focal epilepsy could be considered.[31,32] Underpinning this view is the concept that these usually benign, self-limited, focal epilepsies of childhood are due to nonspecific "maturational delay," rather than a specific structural lesion or genetic aberration.[33–35] Although a life-long risk of epilepsy cannot be excluded in children with CP, the temporary coexistence of an age-limited epileptic syndrome should be considered, especially in children with WMI.

This study has important practical implications for the management of children with CP and WMI, and potentially children with epilepsy associated with other developmental disorders. Pediatricians need to be aware of these common, epileptic syndromes of childhood, as well as their occurrence in children with CP. This awareness may require pediatricians to question neurologists as to whether EEG reports with frequent epileptiform multifocal IEDs are CTS or OS and whether treatment is needed. Parents of children with CP and WMI should be counseled that their child's epilepsy will likely remit, although it may evolve to another epileptic syndrome before remitting. Pediatricians should consider that seizures with fever and afebrile focal seizures in children with CP may not need AED treatment. Finally, certain AEDs should be used with caution or avoided, and AED treatment should not be prolonged due to concern about the underlying brain abnormality or persistence of IEDs on EEG during childhood.

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ABBREVIATIONS

AED: antiepileptic drug
CECTS: childhood epilepsy with centrotemporal spikes
CP: cerebral palsy
CTS: centrotemporal spikes
EOCOE: early-onset childhood occipital epilepsy
GSW: generalized spike-wave
IED: interictal epileptiform discharge
IQR: interquartile range
OS: occipital spikes
WMI: white matter injury

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