Benign pediatric localization-related epilepsies
Part II. Syndromes in childhood

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ABSTRACT – By definition, benign epilepsy syndromes occur in patients with no significant prenatal, perinatal, or postnatal complications, normal psychomotor development and negative laboratory and neuroimaging work-up, respond well to therapy, and remit without sequelae. The benign localization-related epilepsy syndromes of childhood include benign childhood epilepsy with centrotemporal spikes, Panayiotopoulos syndrome and Gastaut-type idiopathic childhood epilepsy with occipital paroxysms. Some patients initially presumed to have these or, for that matter, other benign syndromes in other age groups, follow a less typical course and continue to experience seizures or to exhibit neuropsychological deficits. Thus the diagnosis of a “possible” or “probable” benign epilepsy syndrome may need to be applied to patients initially suspected of having such syndromes until follow-up shows that they clearly follow a benign course. In Part I (Chahine and Mikati 2006) of our two-part review article, we discussed benign localization-related syndromes encountered in infancy. In this second part, we review the epidemiology, clinical manifestations, neuropsychological features, EEG findings, work-up and diagnostic criteria, differential diagnosis, genetics, management and prognosis of the three childhood-onset syndromes. In addition, we discuss their occasional overlap with or progression into other syndromes.

Key words: benign localization-related epilepsy syndrome, rolandic epilepsy, Panayiotopoulos syndrome, Gastaut-type occipital epilepsy

In this second part of our two-part review (Chahine and Mikati 2006) of the pediatric benign localization-related epilepsy syndromes, the benign localization-related epilepsy syndromes of childhood are reviewed (see table 1 for abbreviations).

Benign childhood epilepsy with centrotemporal spikes (BECTS)

Epidemiology
BECTS is the most common localization-related epilepsy syndrome among school-aged children (Ericksson and Koivikko, 1997, Sindevall et al. 1993). It accounts for up to 23% of new-onset childhood epilepsy disorders (Wirrell 1998) and has a male predominance (Beaussart, 1972, Ma and Chan, 2003).

Clinical manifestations
Onset of BECTS occurs between the age of three and 13 years, with a peak incidence around 8-9 years (Kramer et al. 2002, Beaussart, 1972). A history of febrile convulsions, particularly complex febrile convulsions,
present in up to 16% and a history of neonatal and infantile seizures in 1%-8% of cases (Wirrell, 1998, Beaussart, 1972, Ma and Chan, 2003).

**Typical clinical manifestations of BECTS**

The majority of seizures are nocturnal, occurring shortly after sleep-onset or before awakening in 65% of patients, although strictly diurnal seizures or both nocturnal and diurnal seizures may also occur (Wirrell, 1998, Manelis and Dublin, 1995, Beaussart, 1972).

Seizures are somatosensory at onset, with symptoms including unilateral tongue, gum, lips, or inner cheek paresthesias, jaw and tongue stiffness or a sensation of choking. Less commonly, jerking or paresthesias of a limb, usually the arm, loss of vision, abdominal pain, or vertigo are reported (Manelis and Dublin, 1995, Wirrell, 1998). In 12% of the patients, this may be the sole manifestation of the seizure (Ma and Chan, 2003). In 34%, it is followed by unilateral or generalized convulsions that are either tonic, clonic, or tonic-clonic, most commonly involving the face, lips, tongue, or muscles of the pharynx and larynx (Ma and Chan, 2003, Manelis and Dublin, 1995, Lerman and Kivity, 1975, Holmes, 1993), the latter leading to speech arrest or anarthria and excessive drooling. A combination of different seizure types may occur in the same child (Kramer et al. 2002). Occasionally, partial motor seizures may change from one side of the body to the other without secondary generalization (Wirrell, 1998). In up to 54%, generalized seizures without a clinically apparent focal onset may occur (Ma and Chan, 2003). BECTS seizures have been categorized into three types: i) hemifacial seizures with anarthria and drooling, with preservation of consciousness, ii) as described in (i) but with alteration of consciousness, often accompanied by gurgling noises or grunting, iii) with secondarily generalized tonic-clonic seizures (Wirrell, 1998, Manelis and Dublin, 1995, Beaussart, 1972).

Seizures typically last seconds to minutes. Seizure frequency varies: 10-13% of patients will have only one seizure, 70% have seizure recurrences at 2-12 month intervals, and 20% have daily seizures (Manelis and Dublin, 1995, Wirrell, 1998). In 62% of cases, 2-5 seizures will occur. Seizure onset prior to the age of three may predict the likelihood of multiple seizures (Kramer et al. 2002, Bouma et al. 1997).

**Atypical clinical manifestations of BECTS**

Atypical features are relatively common, occurring in up to 50% of patients. They may be more common among those with seizure-onset before 6 years of age. Developmental delay and diurnal-only seizures predict the occurrence of other atypical clinical features (Wirrell et al. 1995).

Atypical features include leg jerking, lateral body torsion, unilateral body sensations, epigastric pain, ictal blindness, status epilepticus, diurnal-only seizures, developmental delay, Todd’s paresis, and an attention deficit disorder (Wirrell et al. 1995, Vinayan et al. 2005, Manelis and Dublin, 1995).

Partial status epilepticus occurs in up to 17% of cases of BECTS (Wirrell, 1998). The clinical picture includes slurred speech, constant drooling, oromotor dyspraxia, atonic nodding of the head, or facial myoclonias. These symptoms have been likened to those seen in opercular syndromes, in which bilateral opercular lesions or, in this case, ongoing seizure activity, are associated with loss of voluntary control of facial, pharyngeal, lingual, masticatory, and sometimes ocular muscles, while reflex and automatic function of these muscles remains intact (Gregory et al. 2002, Kramer et al. 2001, Saint-Martin et al. 1999, 2001a). This clinical picture correlates with the presence of continuous spike-waves during slow sleep (Fejerman et al. 2000).

**Neuropsychological features of BECTS**

Between 28% (Massa et al. 2001) and 53% (Vinayan et al. 2005) of children with BECTS display neuropsychological abnormalities during the active phase of the syndrome including cognitive dysfunction, with difficulties on

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**Table 1. Abbreviations used.**

<table>
<thead>
<tr>
<th>ABFCE</th>
<th>Atypical benign focal childhood epilepsy (pseudo Lennox-Gastaut syndrome)</th>
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<tbody>
<tr>
<td>BCEOP</td>
<td>Benign childhood epilepsy with occipital paroxysms</td>
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<tr>
<td>BECTS</td>
<td>Benign childhood epilepsy with centrotemporal spikes</td>
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<tr>
<td>CT</td>
<td>Centrotemporal</td>
</tr>
<tr>
<td>CSWSS</td>
<td>The EEG finding of continuous spike-waves during slow-wave sleep</td>
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<tr>
<td>ECSWSS</td>
<td>Epilepsy with continuous spike-waves during slow-wave sleep</td>
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<tr>
<td>IEDs</td>
<td>Interictal discharges</td>
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<td>LKS</td>
<td>Landau-Kleffner syndrome</td>
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auditory-verbal and visuospatial memory and executive function tasks, language impairment, attention disorders, learning disabilities, and behavioral disturbances (Pinton et al. 2005, Sart et al. 2006, Croona et al. 1999, Saint-Martin et al. 1999, Ong and Wyllie, 2000, Wirrell, 1998; Vinayan et al. 2005, Deonna et al. 2000). The types of cognitive deficits correlate with the side of the centrotemporal (CT) abnormalities (Wirrell, 1998). For example, right hemisphere foci may interfere with visuospatial processing (Pinton et al. 2005, Piccirilli et al. 1994). Cognitive deficits are more likely to occur when interictal abnormalities are bilateral (Massa et al. 2001). A spike frequency of > 10/minute may be more likely to lead to language delay and cognitive/behavioral problems. Also, atypical seizure semiology often correlates with language dysfunction (Baglietto et al. 2001, Vinayan et al. 2005, Nicolai et al. 2006).

EEG findings in BECTS

Although mild background slowing is occasionally noted, EEG background activity is usually normal in BECTS. Interictal EEG shows high-voltage, diphasic or negative spikes, followed by prominent slow waves of less amplitude at the midtemporal (T3, T4) and central (rolandic) regions (C3, C4) (Wirrell, 1998, Minami et al. 1996, Holmes, 1993, Beaussart, 1972). Spike frequency varies from one patient to another, and may vary in the same patient from one EEG to another (Holmes, 1993). Spikes occur individually or in clusters. Horizontal dipoles are common, with maximal negativity in the centrotemporal area and positivity in frontal regions (Kamada et al. 1998, Gregory and Wong, 1992) (figure 1). Marked activation of spikes occurs characteristically during drowsiness and sleep (Wirrell, 1998). The focus is unilateral in 55%-70% of cases and bilateral in 42% (Drury and Beydoun, 1991). When bilateral, they are either synchronous or more commonly asynchronous in terms of both the rate of firing and amplitude (Lerman and Kivity, 1975, Beaussart, 1972). Spikes are typically present in both central and temporal regions, but may shift location (Beaussart, 1972, Drury and Beydoun, 1991) or may occur exclusively in midtemporal or central regions (Holmes, 1993). Atypical spike locations occur in 17%-21% of patients. Many children who initially have occipital spikes are later found to have centrotemporal spikes (Wirrell, 1998, Holmes, 1993, Drury and Beydoun, 1991). There is a poor correlation between EEG findings and the clinical picture (Holmes, 1993). Voluntary tongue or mouth movements, or contralateral hand or finger movements have been shown to inhibit centrotemporal spikes (Gregory et al. 2002, Colamarina et al. 1991). The presence of dipole centrotemporal spikes implies a better prognosis, and lesser risk of

![Figure 1. Interictal EEG in a child with BECTS showing a horizontal dipole: the sharp waves are of negative polarity in the right central and midtemporal regions and positive in the frontal regions (reproduced with kind permission of Blackwell Publishing from Drury I. EEG in benign and malignant epileptic syndromes of childhood. *Epilepsia* 2002; 43 (Suppl. 3): 17-26).](image-url)
seizures, developmental delay, abnormalities on neurological examination, and of academic difficulties (Gregory and Wong, 1992). Six interictal EEG patterns have been shown to correlate with atypical BECTS: intermittent slow-wave foci, multiple asynchronous spike-wave foci, long clusters of spike-waves, generalized 3 Hz/second spike-wave discharges, conjunction of interictal discharges with negative or positive myoclonias, and an abundance of interictal abnormalities during both wakefulness and sleep. The occurrence of three of these six patterns was suggested to be predictive of those BECTS patients at higher risk of poor academic performance, inattention, impulsivity, decreased short-term memory, and other neuropsychological deficits (Massa et al. 2001). Generalized 3Hz spike-wave discharges and absence seizures may also occur in BECTS patients, although this is rare (Gelisse et al. 1999).

Centro-temporal spikes, or Rolandic spikes, are a common finding and only 5% of these children will manifest BECTS (Wirrell, 1998). Up to 5.6% of ADHD patients exhibit centrotemporal spikes on EEG (Holtmann et al. 2003) and central spikes with a BECTS-like morphology are seen in a number of clinical syndromes besides BECTS (Holmes, 1993, Manelis and Dublin, 1995).

**Ictal EEG recordings** during a nocturnal seizure in a child in stage II sleep initially showed low-voltage, fast activity originating in the centrotemporal area unilaterally and spreading over the entire ipsilateral then contralateral hemisphere (Dalla-Bernardina and Tassinari, 1975). Ictal EEG recordings of a diurnal seizure showed focal decremental activity in the centrotemporal region followed by dense spikes in the same location. Seizure activity did not spread to adjacent brain areas and there was no postictal slowing (Wirrell, 1998).

Intercital EEG and magnetoencephalographic (MEG) analysis studies have shown the epileptogenic focus of BECTS to be localized to the radial somatosensory cortex (Minami et al. 1996), in the inferior Rolandic (face) or superior Rolandic (hand) regions (Kamada et al. 1998).

**Work-up and diagnostic criteria**

In one report, BECTS was misdiagnosed in 84% of cases by a general pediatrician (Ma and Chan, 2003). Considering the benignity of BECTS, correct diagnosis is essential. A sleep EEG is necessary, particularly if the awake EEG shows no abnormalities (Panayiotopoulos, 1993). Typical EEG findings, accompanied by a typical clinical history and negative neurological examination, are generally considered sufficient to make the diagnosis of BECTS (Wirrell, 1998).

The diagnostic criteria of BECTS include: i) brief, stereotypical, simple partial, unilateral facial motor seizures associated with somatosensory symptoms, and a tendency for secondary generalization, commonly occurring in sleep; ii) seizure-onset between the ages of 3-13; iii) spontaneous recovery before the age of 16; iv) absence of anatomic CNS lesions that could be related to the epilepsy; and v) no history or current neurological or intellectual deficit (Engel 2001, Commission on Classification and Terminology of the International League Against epilepsy 1989).

Although BECTS is defined as a benign syndrome, implying in the strictest sense its occurrence in otherwise healthy children with normal neuroimaging, there are several reports of BECTS occurring in children with non-Rolandic CNS pathology (Beaussart, 1972; Kramer et al. 2002, Lundberg et al. 1999, Stephani and Doose, 1999, Santanelli et al. 1989, Shevell et al. 1996). In a series of 71 BECTS cases (Gelisse et al. 2003), 14% were found to have rather non-specific abnormalities on neuroimaging, the most common being enlargement of the ventricles. However, all cases had typical EEG features of BECTS and final recovery occurred in all cases that reached puberty.

Several authors consider that neuroimaging is unnecessary in typical cases of BECTS. In the presence of atypical electroclinical features or abnormalities on neurological examination, an MRI is advocated (Shevell et al. 1996, Wirrell, 1998, Holmes, 1993, Gelisse et al. 2003). Because the course of BECTS in children with lesions found on neuroimaging is as favorable as in children with no CNS pathology (Lerman and Kivity, 1975), and considering the relatively high incidence of BECTS, many agree that the occurrence of BECTS in a child with CNS pathology is coincidental. However, others suggest that a brain lesion may lower the epileptogenic threshold in children with centrotemporal spikes (Santanelli et al. 1989, Gelisse et al. 2003). Shevell et al. (1996) have proposed that focal lesions, occurring during a particular time of brain development, and brain malformations, mimic the electroclinical features of BECTS, and called this syndrome pseudo-BECTS.

**Differential diagnosis**

Differentiating BECTS seizures from other partial seizures based on EEG findings is straightforward. Clinically, BECTS is differentiated from complex partial temporal lobe seizures by the absence of aura, automatisms, and psychic phenomena in BECTS (Manelis and Dublin, 1995). Several clinical features distinguish BECTS from BCEOP (see below). While CSWSS can occur in or can evolve in both Landau-Kleffner syndrome (LKS) and BECTS, BECTS may still be differentiated from LKS by the absence of a distinct, progressive, and prolonged language deficit in the former. The distinction between partial status epilepticus of BECTS and atypical benign idiopathic focal epilepsy lies in the fact that atonic seizures are the most prominent feature of the latter (Gregory et al. 2002, Arzimanoglou et al. 2004).
Genetics of BECTS

The prevalence of BECTS and other seizure types is increased in the relatives of patients with BECTS (Wirrell, 1998). The EEG finding of centrotemporal spikes suggests an autosomal dominant mode of inheritance (Bray and Wiser, 1964). However, the clinical syndrome of BECTS is considered to have a complex and multi-factorial mode of inheritance (Vadalamudi et al. 2006, Wirrell, 1998). A linkage analysis study has shown a susceptibility locus in a region of chromosome 15q14, with peak scores found in a region coding for the alpha 7 subunit of the acetylcholine receptor (Neubauer et al. 1998).

Two other BECTS-associated genetic syndromes have been reported. Autosomal dominant rolandic epilepsy with sleep dyspraxia—a syndrome combining features of BECTS, LKS, and epilepsy with continuous spike-waves during sleep (CSWSS)—is autosomal dominant with 100% penetrance for speech dyspraxia, and writer’s cramp, linkage analysis revealed a common homozygous haplotype within the region on chromosome 16p12-q12 linked to infantile convulsions and choreoathetosis (ICCA) (Guerrini et al. 1999, Szepetowski et al. 1997).

Management and prognosis of BECTS

Because isolated, single seizures occur in up to 13% of cases, it is generally agreed upon that AED therapy should be withheld following the first seizure (Wirrell, 1998, Lerman and Kivity, 1975, Ambrosetto and Tassinari, 1990). Proposed indications for AED therapy include a second seizure, seizure-onset prior to the age of four, recurrent generalized tonic-clonic seizures, and diurnal seizures (Wirrell, 1998, Al-Twaijri and Shevell, 2002, Bouma et al. 1997, Loiseau et al. 1998). AED therapy may not affect seizure frequency, number of seizures, or duration of active epilepsy (Ambrosetto and Tassinari, 1990). Carbamazepine is the most commonly used, initial AED. It is successful in controlling seizures in 50-65% of patients (Wirrell, 1998). Other AEDs used with success include: clonazepam (Mitsudome et al. 1997), levetiracetam (Bello-Espinosa and Roberts, 2003), gabapentin (Bourgeois et al. 1998), phenytoin, valproate, clobazam, primidone, and phenobarbital (Boura et al. 1997; Prats et al. 1997). Sulthiame, in a randomized controlled trial, produced initial response rates of 96% (Rating and Wolf, 2000, Doose et al. 1988).

The rare aggravation of BECTS by AEDs has most commonly been reported with carbamazepine, phenobarbital, and less frequently with valproate (Papazian et al. 1995, Corda et al. 2001). The exacerbation is often associated with the development of CSWSS (Prats et al. 1997). Prats et al. (1997) reported six patients treated with carbamazepine or valproate who exhibited worsening of clinical seizure and neuropsychological deterioration, with evolution to LKS in four and ABFCE with or without an operculum-like syndrome in two. Discontinuation of the drug and initiation of alternative therapy resolved the exacerbation in all reported cases.

Failure of AED therapy to control seizures within one year from initiation varies from 14-30%, although this may not correlate with final outcome (Wirrell, 1998). The presence of atypical clinical features may not necessarily influence response to AEDs (Wirrell et al. 1995). Length of therapy is controversial; one year may be sufficient (Braathen et al. 1996). The relapse rate following AED discontinuation is approximately 14% (Bouma et al. 1997).

The natural course of BECTS is one of resolution by mid-adolescence. The mean duration of active seizures is less than three years (Bouma et al. 1997). Age-at-seizure cessation ranges from a mean age of 9.6 years (Loiseau et al. 1998) to 10.4 years (Kramer et al. 2002). Earlier remission occurs in those with seizure-onset after the age of four (Wirrell, 1998) and those with sporadic seizures or seizures that occur in clusters. Between 98% (Loiseau et al. 1998) to 99.8% (Bouma et al. 1997) remain in remission beyond 18 years of age. However, the relative risk of subsequent GTCS in BECTS patients was found to be ten times greater than that of the general population (Loiseau et al. 1998).

While neuropsychological deficits are common during the active phase of the disease, they typically remit following remission of seizures and EEG abnormalities, although mild deficits in executive function may persist (Baglietto et al. 2001, Lindgren et al. 2004, Loiseau et al. 1998, Deonna et al. 2000, Loiseau et al. 1983). BECTS patients followed-up into adulthood have average or above average social and occupational adjustment (Loiseau et al. 1983, Loiseau et al. 1998).

Doose and Baier, (1989) have proposed that “BECTS is only one part of a spectrum caused by a ‘hereditary impairment of brain maturation’ “, and suggested that patients along the spectrum have specific, inherited EEG features; their place on the spectrum depends on several factors, including localization, the extent of brain maturation or its disturbance thereof, and other genetic and environmental factors. Other disorders in this spectrum include: benign partial epilepsy with extreme somatototopy evoked potentials; benign childhood epilepsy with focal symptoms; benign childhood epilepsy with occipital paroxysms; atypical benign focal childhood epilepsy; epilepsy with continuous spike-waves during slow sleep and Landau-Kleffner syndrome.

Atypical evolutions of BECTS

Certain patients with status epilepticus of BECTS, atypical evolutions of BECTS, and atypical evolutions of BCEOP (Caraballo et al. 2001, Tenembaum et al. 1997, Fejerman et al. 1991) develop CSWSS and clinical features that overlap with LKS, ECSWSS or ABFCE. Together, these patients show several electroclinical features typical of the...
epileptic encephalopathies in which CSWSS occur (figure 2).

Fejerman et al. (2000) described, among 378 BECTS cases, 26 children with normal initial psychomotor development, normal neuroimaging, and no abnormalities on neurological examination but who later exhibited the atypical evolutions of BECTS. Thus, less than 1% of children with BECTS will evolve to have more complicated disorders. Based on EEG or early seizure characteristics, it is not possible to predict an atypical evolution (Fejerman et al. 2000, Nicolai et al. 2006).

Atypical partial benign epilepsy (ABFCE), described by Aicardi and Chevrie (1982) and also termed “pseudo-Lennox syndrome” (Hahn, 2000) is characterized by rare, focal and often nocturnal seizures, and by periods, usually of a few weeks in duration, in which intense clinical and EEG epileptic activity is evident. During these periods, the seizures are characteristically atonic attacks that can be focal or generalized and that can result in multiple daily falls. The EEG abnormalities include brief discharges of spike-waves associated with the falls and CSWSS. The cognitive and behavioral outcome may be favorable, but deterioration may also occur, especially when multiple and long bouts of seizures occur. This condition probably represents an intermittent form of the syndrome of CSWSS (Arzimanoglou et al. 2004). In addition to idiopathic ABFCE, a symptomatic variant in which patients exhibit similar electroclinical features but who are found to have gross brain abnormalities on neuroimaging, has also been reported (Aicardi, 2000). Similarly, a minority of patients with BECTS will, years later, develop LKS with CSWSS on EEG (Fejerman et al. 2000, Aicardi, 2000).

Figure 2. The epileptic encephalopathies of childhood include ABFCE, LKS, and ECSWSS. In addition, atypical evolutions of BCEOP, partial status epilepticus of BECTS, and atypical evolutions of BECTS share several overlapping electroclinical features with each other and with the other epileptic encephalopathies of childhood with the EEG finding of CSWSS. BCEOP = benign childhood epilepsy with occipital paroxysms. BECTS = benign epilepsy with centrotemporal spikes. ECSWSS = epilepsy with continuous spike-waves during slow-wave sleep. ABFCE = atypical benign focal childhood epilepsy (pseudo-Lennox Gastaut). LKS = Landau-Kleffner syndrome.
Benign childhood epilepsy with occipital paroxysms (BCEOP)

Benign childhood epilepsy with occipital paroxysms (BCEOP), initially described by Gastaut (1982), has been classified under the idiopathic, localization-related epilepsies (Commission on Classification and Terminology of the International League Against epilepsy, 1989). However, with the recognition of a distinct entity with an earlier age-at-onset described by Panayiotopoulos in 1989, it was proposed to recognize two different syndromes: early-onset benign occipital seizure susceptibility syndrome (Panayiotopoulos syndrome) and late-onset childhood occipital epilepsy (Gastaut type BCEOP) (Engel, 2001). They will be referred to as Gastaut-type BCEOP and Panayiotopoulos-type BCEOP. Similarities and differences between the two conditions are summarized in table 2.

Epidemiology

In one series, Gastaut-type BCEOP constituted 0.15% of all localization-related epilepsies (Oguni et al. 1999). The prevalence of Panayiotopoulos-type BCEOP is reported to range from 6.7% (Lada et al. 2003) to 13% among children with localization-related epilepsies (Oguni et al. 1999, 2001).

Clinical manifestations of Panayiotopoulos-type BCEOP

Onset is reported between the ages of two and twelve years, with a mean age of five years. Large cohorts have not demonstrated gender predominance (Panayiotopoulos, 1999b). There is a history of febrile seizures in 4.4% (Lada et al. 2003) to 25% (Caraballo et al. 2000), and a history of migraine in 13% (Oguni et al. 1999). Seizures are nocturnal in 80% (Lada et al. 2003, Caraballo et al. 2000). Seizure onset is usually marked by ictal vomiting, although only nausea or retching may occur. While vomiting has been cited to occur as the initial event in 60-80% (Lada et al. 2003, Koutroumanidis, Panayiotopoulos, Oguni et al. 1999), others have reported a frequency of only 44% (Kivity et al. 2000). Vomiting is accompanied or followed by tonic eye, and less commonly head, deviation in 70-98% (Oguni et al. 1999, Caraballo et al. 2000). Alternatively, tonic eye deviation was reported to occur without vomiting. In one series of 134 patients, 100% had tonic eye deviation whereas only 44% had ictal vomiting (Kivity et al. 2000). Autonomic manifestations, including urine incontinence, pallor, perioral cyanosis, hypersalivation, and rarely, ictal headache and fecal incontinence may occur (Lada et al. 2003, Ferrie and Grunewald, 2001, Koutroumanidis, 2002). Impairment of consciousness is invariable (Lada et al. 2003). Rarely, BECTS-like features such as speech arrest, hemifacial spasm, and oropharyngeal involvement also occur (Covanis et al. 2003, Koutroumanidis 2002, Caraballo et al. 1998). Visual hallucinations are rare, occurring in less than 10% (Panayiotopoulos 2001, Caraballo et al. 2000).

In 30-50% of patients, progression to hemiconvulsions or generalized tonic-clonic seizures (GTCS) occurs (Lada et al. 2003, Panayiotopoulos 2001, Koutroumanidis 2002, Oguni et al. 1999). Partial or complex partial status epilepticus, marked by tonic eye or head deviation, with or without concomitant vomiting occurs in 30%-50% of cases. The occurrence of status epilepticus is more common in those with ictal vomiting (Koutroumanidis 2002, Oguni et al. 1999, Kivity and Lerman 1999). Partial status epilepticus evolves into hemiconvulsions in up to 34% and secondarily generalizes in 16%-25% (Ferrie et al. 1997, Caraballo et al. 2000). In 33% of cases, seizures last 2 to 10 minutes (Kivity et al. 2000, Kivity and Lerman 1999). Seizure frequency is highly variable, ranging from an isolated seizure in 18-53% to more than several seizures per month in 5-26% (Koutroumanidis 2002, Caraballo et al. 2000, Oguni et al. 1999, Lada et al. 2003, Ferrie et al. 1997). Status epilepticus may occur recurrently, particularly in children with younger age-at-seizure onset and in those with ictal vomiting (Oguni et al. 2001, Kivity et al. 2000). Patients with even the most florid, prolonged seizures will return to baseline after a few hours (Koutroumanidis 2002, Ferrie and Grunewald 2001).

Clinical manifestations of Gastaut-type BCEOP

The Gastaut-type BCEOP begins later in life, between the ages of 3-16 years, with a mean age of 7.4-8 years. There is no sex predominance (Panayiotopoulos 1999b). Seizures are diurnal in over 80% (Kivity et al. 2000). Seizure onset is marked by visual phenomena, most commonly amaurosis (Gastaut 1982), or elementary or complex visual hallucinations (Panayiotopoulos 1999a). In 44% of Gastaut’s original series (1982), visual hallucinations were followed by hemiconvulsions or automatisms, with or without secondarily generalization. Adverse manifestations may accompany the visual phenomena or occur alone in a minority. Ictal vomiting and headache rarely occur; postictal, migrainous headache, with or without nausea and/or vomiting occurs in 25% (Panayiotopoulos 1999a).

Seizure duration is typically less than 5 minutes (Tsai et al. 2001); visual hallucinations last one to 3 minutes and ictal blindness usually lasts 3 to 5 minutes (Panayiotopoulos 1999a). Status epilepticus marked by behavioral and cognitive disturbances may rarely occur (Panayiotopoulos 1999a, Caraballo et al. 2000). During the visual hallucinations, consciousness is preserved but may be altered should the seizure progress. Isolated seizures rarely occur; more than two-thirds of patients will have at least four seizures; many will have daily to monthly seizures (Panayiotopoulos 1999b, Kivity et al. 2000, Tsai et al. 2001).
Table 2. Comparison of Gastaut-type BCEOP and Panayiotopoulos-type BCEOP.

<table>
<thead>
<tr>
<th></th>
<th>Gastaut-type BCEOP</th>
<th>Panayiotopoulos-type BCEOP</th>
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<tbody>
<tr>
<td><strong>Epidemiology</strong></td>
<td>Constitutes 0.15% of cases of childhood localization-related epilepsies</td>
<td>Constitutes 13% of cases of childhood localization-related epilepsies</td>
</tr>
<tr>
<td><strong>Age-at-onset</strong></td>
<td>3-16 with a mean age of 7.4-8 years</td>
<td>2-12 with a mean age of 5 years</td>
</tr>
<tr>
<td><strong>Most prominent clinical manifestations</strong></td>
<td>Diurnal in over 80% Visual phenomena at seizure-onset, usually accompanied by aversive manifestations, with or without secondary generalization, Postictal migrainous headache, with or without nausea and/or vomiting Status epilepticus rare</td>
<td>Nocturnal in 80% Ictal vomiting and/or tonic eye deviation at seizure onset Autonomic manifestations in some Progression to hemiconvulsions or GTCS in 50% of patients Status epilepticus common</td>
</tr>
<tr>
<td><strong>Visual hallucinations</strong></td>
<td>Often present</td>
<td>Rare</td>
</tr>
<tr>
<td><strong>Ictal vomiting</strong></td>
<td>Rare</td>
<td>Often present</td>
</tr>
<tr>
<td><strong>Impairment of consciousness</strong></td>
<td>Rare unless seizure progresses</td>
<td>As a rule initially not present (simple partial) then occurs in almost all (complex partial)</td>
</tr>
<tr>
<td><strong>Seizure frequency</strong></td>
<td>Isolated seizures rarely occur Majority have at least four seizures; many have daily to monthly seizures</td>
<td>Highly variable One third to half have isolated seizures</td>
</tr>
<tr>
<td><strong>Seizure duration</strong></td>
<td>Seizure duration typically less than 5 minutes Visual hallucinations last 1-3 minutes Ictal blindness lasts 3-5 minutes</td>
<td>Seizure duration 2-10 minutes in one-third of patients Autonomic status, lasting longer than 30 minutes, in one third to half</td>
</tr>
<tr>
<td><strong>Interictal EEG</strong></td>
<td>Occipital spikes usually showing fixation off sensitivity (block with eyes open while fixing)</td>
<td>Spikes most commonly occipital but often multi-focal, frequently parietal</td>
</tr>
<tr>
<td><strong>Ictal EEG findings</strong></td>
<td>Cessation of sharp-wave occipital discharges followed by 10 Hz spike discharges or other fast rhythms in the occipital region and then slow monomorphic activity or spike-waves localized to the posterior areas</td>
<td>Rhythmic monomorphic decelerating theta or delta activity Often initially occipital and lateralized at onset with later spread to other regions, though ictal onset in other areas has been described</td>
</tr>
<tr>
<td><strong>Dipole of occipital spikes</strong></td>
<td>Superficial</td>
<td>Deep</td>
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<td><strong>Diagnostic criteria</strong></td>
<td>Normal psychomotor development Normal neuroimaging</td>
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<td>Age of seizure onset between 3-16 Seizures marked by ictal blindness and/or visual hallucinations that may be followed by hemiconvulsions Occipital EEG foci with or without foci migration or foci in other locations Remission by late teenage-hood</td>
<td>Age of seizure onset between 2-12 years Infrequent partial seizures marked by vomiting and tonic eye and/or head deviation with or without hemiconvulsions or secondary generalization Occipital EEG foci with or without foci migration or foci in other locations Seizure remission by age 12</td>
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<td><strong>Prognosis</strong></td>
<td>In 60%, remission occurs in the late teens In 30-40% of cases, visual seizures with or without secondary GTCS continue to occur and become difficult to control</td>
<td>In 50-60%, remission occurs within 1-2 years of seizure onset Majority of patients remit by age 12</td>
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</table>

**Neuropsychological features of BCEOP**

To our knowledge, the neuropsychological features of Gastaut-type BCEOP have not been studied. During the active phase of their disease, Panayiotopoulos type BCEOP patients show lower IQ scores compared to controls (Oguni et al. 2001), and verbal tasks are particularly impaired. They have an increased frequency of selective learning disabilities, and perform significantly lower on tasks of manual dexterity, global visual perception, visual-motor integration, and visual attention compared to controls (Germano et al. 2005).
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EEG findings in BCEOP

Panayiotopoulos-type BCEOP and Gastaut-type BCEOP share similar interictal EEG features (Ferrie et al. 1997, Gastaut, 1982, Verroty et al. 2000, Tsai et al. 2001), although differences, particularly in sleep EEG recordings, have been reported (Panayiotopoulos 1989, Fejerman 1997, Caraballo et al. 1994). Background activity is normal. In the majority of patients, interictal EEG is marked by high amplitude (200-300 μV) spikes followed by slow-wave discharges recurring rhythmically at 2-3 second intervals, classically described as being in the occipital region, although it is increasingly being recognized that this is not systematically the case in Panayiotopoulos-type BCEOP (Ferrie et al. 1997, Panayiotopoulos, 1999a, Gastaut, 1982). Most occipital paroxysms occur during eye closure and are suppressed by eye-opening (Tsai et al. 2001, Panayiotopoulos, 1999a). They may be bilateral or unilateral, in which case they are more often right-sided (Lada et al. 2003, Tsai et al. 2001). These spike-waves may be synchronous or asynchronous, and symmetric or asymmetric.

That the dipole of occipital spikes is superficially located in Gastaut-type BCEOP (Van der Melj et al. 1997) but not in Panayiotopoulos-type BCEOP (Yoshinaga et al. 2005) may account for the absence of visual symptoms in most Panayiotopoulos syndrome cases. Fixation-off sensitivity (FOS), the occurrence of interictal discharges as the result of elimination of central vision and fixation, is a feature of both types of BCEOP (Panayiotopoulos, 1989, Panayiotopoulos, 1998a). Fixation-off sensitivity occurs less commonly in other conditions as compared to BCEOP (Kivity et al. 2000, Panayiotopoulos, 1998a). Intermittent photic stimulation and sleep do not increase the occurrence of spike-waves in Gastaut-type BCEOP, but this has been rarely reported to occur in Panayiotopouous-type BCEOP (Gastaut, 1982, Lada et al. 2003).

EEG findings in Panayiotopoulos-type BCEOP

Interictal EEG is initially normal in up to 25% of cases (Kivity et al. 2000); discharges will be seen in subsequent EEGs in the majority (Panayiotopoulos, 1999b, Guerrini et al. 1997). While spikes are classically occipital, many patients have spikes in other regions, either alone or in combination, in parietal, centrotemporal, frontal, multifocal, or brief bursts of generalized spike-waves (Lada et al. 2003, Koutroumanidis, 2002, Caraballo et al. 2000, Kanazawa et al. 2005). Combinations of occipital spikes with any of the latter may also occur. In fact, the frequently parietal origin of discharges has led some to question the accuracy of classifying the Panayiotopoulos-type BCEOP as occipital epilepsy (Kanazawa et al. 2005). Recently, it has been suggested to classify this syndrome as an aetonic form of epilepsy (Ferrie et al. 2006). Clinical manifestations do not vary according to spike location or frequency (Lada et al. 2003). In some cases, occipital spikes on EEG will only be present postictally (Kivity et al. 2000). Occipital spike-waves on EEG shift in location to more anterior sites with increasing age (Oguni et al. 1999, Oguni 2001, Ohtsu et al. 2003).

Vigevano et al. (2000) reported on an ictal EEG of a Panayiotopoulos-type BCEOP. The tracing showed rhythmic or arrhythmic, high amplitude slow waves of 2 Hz frequency, with intermixed spikes or polyspikes with right occipital localization that later spread to right temporal and contralateral occipital regions. This activity did not vary throughout the seizure. The seizure ended abruptly with diffuse, low voltage activity, followed by postictal delta rhythm activity of high voltage in the right occipital region that lasted for several minutes. Others have also reported ictal shifting of initially unilateral occipital spikes to bilateral occipital regions. In another description of an ictal EEG, cessation of occipital paroxysms and the occurrence of sharp rhythms in the occipital region, progressing to monomorphic theta activity bilaterally, were described (Panayiotopoulos, 1999a). Others have reported origination of seizure discharges in extra-occipital areas, such as the unilateral frontal region in one report (Oguni et al. 2001).

MEG studies on Panayiotopouous-type BCEOP patients localized clustered equivalent current dipoles to areas near the parieto-occipital sulcus, calcaneal sulcus, or both in eight patients and to the centrotemporal area in two (Kanazawa et al. 2005).

EEG findings in Gastaut-type BCEOP

Beaumanoir (1983) reported EEG manifestations of a diurnal seizure in a patient with Gastaut-type BCEOP (figure 3). Ictal EEG showed focal rapid spike-waves that progressively slowed. A nocturnal ictal EEG recording showed cessation of sharp-wave occipital discharges followed by 10 Hz spike discharges in the occipital region and then slow, monomorphic activity or spike-waves localized to the posterior areas. Thomas et al. (2003) published a case with a video-recording of several ictal events.

Work-up and diagnostic criteria

The presence of typical electroclinical features is diagnostic of both types of BCEOP although EEG abnormalities are not a prerequisite for the diagnosis of Panayiotopouous-type BCEOP (Ferrie et al. 1997, Gastaut, 1982, Panayiotopoulos, 1989). A sleep EEG should be performed if the EEG is normal in a patient with suspected Panayiotopoulos syndrome (Koutroumanidis, 2002).

Diagnostic criteria of Panayiotopoulos-type BCEOP

The diagnostic criteria of Panayiotopoulos-type BCEOP include: i) normal psychomotor development; ii) normal neuroimaging; iii) age-at-seizure onset between 2-12 years; iv) infrequent partial seizures marked by vomiting and tonic eye and/or head deviation with or without
hemiconvulsions or secondary generalization; v) occipital EEG foci with or without foci migration or foci in other locations; and vi) seizure remission by age 12 (Oguni et al. 1999).

Diagnostic criteria of Gastaut-type BCEOP

The diagnostic criteria of Gastaut-type BCEOP are less well-defined. They should probably include: i) normal psychomotor development; ii) normal neuroimaging; iii) age-at-seizure onset between 3-16; iv) seizures marked by ictal blindness and/or visual hallucinations that may be followed by hemiclonic convulsions; v) occipital EEG foci with or without foci migration or foci in other locations; and vi) remission by late teenagehood.

Differential diagnosis of Panayiotopolous-type BCEOP

The ictus emeticus typical of Panayiotopoulos-type BCEOP rarely occurs in other childhood epilepsies (Panayiotopolous, 1988).

Some patients with Panayiotopoulos syndrome may exhibit features of BECTS; in all these cases other distinguishing features will be present; ictus emeticus, a prominent feature of the syndrome, is very rarely present in BECTS (Covanis et al. 2003). In doubtful cases, an MRI can help differentiate Panayiotopolous-type BCEOP from mesial temporal lobe epilepsy with hippocampal sclerosis (Oguni et al. 1999).

The inaugural event of Panayiotopolous-type BCEOP may be prolonged seizures; this may mistakenly be attributed to a cerebral insult, and extensive concern and undue work-up may ensue. The most reliable feature differentiating Panayiotopolous-type BCEOP from more serious disorders are EEG findings and the return to baseline of the child within a few hours of sleep in the former (Caraballo et al. 2000, Kivity and Lerman, 1992).

Panayiotopolous-type BCEOP may be differentiated from idiopathic photosensitive occipital epilepsy in which ictus emeticus may occur, in that the latter is triggered by photic stimulation and often accompanied by visual hallucinations, blurry vision, or amaurosis (Guerrini et al. 1995, Caraballo et al. 2000).

Differential diagnosis of Gastaut-type BCEOP

Earlier age-at-onset, the presence of ictal vomiting, a nocturnal predominance for seizures, and absence of visual hallucinations that characterize the Panayiotopolous type are helpful, differential diagnosis clues (table 2).

A careful history will differentiate Gastaut-type BCEOP from idiopathic photosensitive occipital epilepsy, as sei-
zures in the former are spontaneous rather than visually induced (Guerini et al. 1995). It was initially suggested that the seizures of what is now known to be BCEOP were manifestations of basilar migraine (Panayiotopoulos, 1980). A detailed history makes the differentiation between occipital seizures and migraine possible (Panayiotopoulos, 1999d). Several features of seizures in Gastaut-type BCEOP patients occur in patients with symptomatic occipital lobe epilepsy, including visual hallucinations and tonic eye deviation. The EEG may be useful in distinguishing between them, but not in all cases. Contrary to what is suggested in patients with BECTS, an MRI is often necessary in patients with a suspicion of Gastaut-type BCEOP in order to eliminate the presence of a lesion indicative of a symptomatic occipital epilepsy. Dipole source analysis may also distinguish the two syndromes (Van der Melj et al. 1997).

Genetics of BCEOP

No single gene has been linked to BCEOP. The occurrence of Gastaut-type BCEOP in several family members has been reported (Kelleman, 1993, Nagendra and Rossiter, 1990). In Gastaut’s (1982) original description of BCEOP, a family history of epilepsy was present in 47% and of migraine in 19%. A history of seizures is present in between 7% (Lada et al. 2003) to 32% (Caraballo et al. 2000, Oguni et al. 2001) of family members of patients with Panayiotopoulos-type BCEOP. Thus, a genetic background predisposing to both types of BCEOP appears likely.

Management and prognosis

Since up to half of Panayiotopoulos-type BCEOP patients experience only one seizure, it is generally agreed upon that initiation of AED therapy is not indicated following the first seizure, but should be considered after the second seizure or following status epilepticus (Lada et al. 2003, Oguni et al. 1999). A higher seizure frequency is more common in Gastaut-type BCEOP and earlier treatment may be indicated (Tsai et al. 2001). For both types of BCEOP, carbamazepine has been the most commonly used AED, although oxcarbazepine, valproic acid, clobazam, and even phenobarbital have also been used (Ferrie et al. 1997, Gastaut, 1982, Verrotti et al. 2000). Withdrawal of treatment within one to two years is generally advised regardless of persistence of EEG abnormalities (Ferrie and Grunewald, 2001, Oguni et al. 1999). As in BECTS, exacerbation of Panayiotopoulos-type BCEOP by carbamazepine therapy has been reported (Kikumoto et al. 2006).


Although one study found no statistically significant difference between the two forms of BCEOP (Tsai et al. 2001), Gastaut-type BCEOP patients are generally cited as having a less certain prognosis. In 60% of these patients, remission is reported to occur in the late teens although persistence of seizures into late teenagehood may occur (Panayiotopoulos, 1999a, Ferrie et al. 1999, Berg and Panayiotopoulos, 1999b). Gastaut (1982) reported, in his original series, that 92% of patients reached full clinical remission by age 19; 53% remitted with initiation of AED therapy. Response rates of up to 90% have been reported (Panayiotopoulos, 1999a, Tsai et al. 2001). In 30-40% of cases, visual seizures with or without secondary generalization continue to occur and become difficult to control (Panayiotopoulos, 1999a, Panayiotopoulos, 1999b).

Intellectual outcome following seizure remission is generally normal, although mild intellectual impairment has been reported to occur in a minority of patients with either type of BCEOP (Ogani et al. 1999, Verrotti et al. 2000).

Special considerations in the treatment of the benign localization-related epilepsy syndromes: interictal EEG abnormalities

Persistence of interictal EEG abnormalities despite remission of clinical seizures is a feature of several benign epilepsy syndromes including BECTS (Wirrell, 1998), BCEOP (Panayiotopoulos, 1989, Caraballo et al. 2000), and the newly defined benign infantile focal epilepsy with midline spikes and waves during sleep (previously known as benign partial epilepsy in infancy and early childhood with vertex spikes and waves (Capovilla and Beccaria, 2000, Capovilla et al. 2006, Chahine and Mikati, 2006). The significance of interictal abnormalities in these patients is unclear, yet they may account for some neurop-
psychological deficits found (Saint-Martin et al. 2001b). Most investigations on this issue have focused on BECTS. BECTS patients exhibit cognitive and behavioral problems during the active phase of their disease (Massa et al. 2001, Weglage et al. 1997, Nicolai et al. 2006). A mild epileptic encephalopathy may account for these abnormalities (Sanchez-Carpintero and Neville, 2003); nocturnal interictal abnormalities are particularly implicated (Baglietto et al. 2001). In the majority, neuropsychological follow-up, following clinical seizure remission, normalizes with the exception of mild deficits in executive function, particularly in tasks of verbal ability (Lindgren et al. 2004).

While sleep organization in BECTS patients is normal (Dalla-Bernardina and Beghini, 1976), approximately 30% of children with BECTS have EEG abnormalities only during sleep (Nicolai et al. 2006), and sleep increases interictal abnormalities (Baglietto et al. 2001). Non-REM sleep has been shown to activate them (Shouse et al. 2004). Sigma activity may play a more important role than slow-wave activity in activating interictal abnormalities in BECTS patients (Nobil et al. 1999). Interictal EEG abnormalities remit spontaneously in the majority; “treatment” of these abnormalities, in the absence of clinical seizures is controversial, but may be of benefit in some cases (Deonna et al. 2000, Baglietto et al. 2001). Sulthiame, diazepam, and clonazepam are reported to decrease EEG discharges in BECTS (Bast et al. 2003, Mitsudome et al. 1997, De Negri et al. 1997). Small studies have found that treatment of nocturnal interictal discharges with diazepam improves cognitive and behavioral problems in BECTS (De Negri et al. 1997, Baglietto et al. 2001). Currently, there are no large, controlled studies that have demonstrated which patients may benefit from such treatment. Treatment in the absence of clinical seizures may also be indicated in some children with cognitive problems that impact daily life (Deonna et al. 2000, Baglietto et al. 2001), but controlled studies are not available.

Conclusion

Over recent decades it has been increasingly recognized that certain patients with epilepsy have no underlying neurological abnormalities, have seizures that respond well to AED therapy, and remit without sequelae. Recent years have seen an increase in studies describing the childhood-localization related epilepsy syndrome BECTS and BCEOP. Though some patients diagnosed with BECTS or BCEOP exhibit atypical evolutions and/or show persistent neuropsychological deficits, the majority of patients with these childhood localization-related epilepsy syndromes follow a truly benign course. Prognosticating at seizure-onset which patients will follow a truly benign course is not possible at this time, hence the utility of using possible, probable, and definite designations while classifying epilepsy syndromes (Chahine and Mikati, 2006). More studies are needed to derive such prognostic information. Studies investigating the significance of interictal EEG abnormalities and how they are best managed are also needed.

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