

# Focal electroencephalographic abnormalities and computerised tomography findings in children with seizures

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## Abstract

**A persistent focal abnormality was observed in 157 (16%) electroencephalograms undertaken in 964 consecutive children with epileptic and non-epileptic seizures seen over one year. CT head scans were performed in 121 (77%) of the 157 children with a focus on the EEG; 26 (21%) showed an abnormality, and 21 (81%) of the abnormalities were localised. There was no difference in the proportion of abnormal scans associated with a delta or slow wave focus compared with a spike or sharp wave focus. An abnormal scan was uncommon after a single seizure. In only two patients (1.7% of all scans) did the findings on CT alter or greatly influence subsequent management.**

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The ability of the EEG to identify structural brain abnormalities was first demonstrated in 1936 when focal slow or delta waves were described in patients with cerebral tumours.<sup>1</sup> These abnormalities are now readily detectable with CT. The correlation between EEG and CT in general, and in patients with epilepsy in particular, is not clear; several studies in both adults and children have found no difference in the number of abnormal CT scans associated with either a normal or an abnormal EEG.<sup>2-5</sup>

In patients with epilepsy, abnormalities localised on CT are of particular clinical relevance because some cases may be amenable to surgical intervention. Although there is no strong correlation between findings on EEG and CT, a focal EEG abnormality, particularly a persistent focal delta wave, increases the likelihood of finding a focal or localised lesion on CT. This has led to suggestions that patients with a focal abnormality on EEG should have a head CT scan.<sup>3,6,7</sup> Others maintain that all patients with seizures, irrespective of findings on EEG, should undergo a head CT scan—not only to identify a potentially treatable lesion but also for the reassurance provided by a normal scan (in the majority of subjects).<sup>8-11</sup> We assessed prospectively the prevalence and nature of abnormalities on CT that were associated with focal EEG abnormalities in a group of unselected children with seizures.

## Methods

All the EEG records were reviewed for children who had been referred for an EEG to a regional paediatric neurophysiology department over a one year period (July 1989 to June 1990). This included patients with single or recurrent epileptic seizures as well as patients with other non-epileptic paroxysmal events. Recordings had been performed in the waking state, over a 30 minute period, using 16 channels with the surface electrodes applied according to the international 10-20 system.

Electrical activity was categorised into delta (0.1-3.5 Hz), theta (4-7 Hz), alpha (8-13 Hz), beta (above 13 Hz) and epileptiform activity (spikes and sharp waves). Patients with a continuous, persistent (frequent but not continuous), or recurring focus of spikes or sharp or slow (delta) waves in the EEG record were recommended to have a CT head scan.

Scans were performed with a third generation Siemens Somatom 2 scanner before and after intravenous contrast and with specific views of the temporal lobes. Records showing symmetric, posterior slow waves of youth, bilateral multifocal abnormalities, and asymmetry of background rhythmic activity (without any focal abnormality) were excluded from the study. Reactiveness of the focal slow wave abnormality was not assessed.

Statistical analysis of the CT and EEG appearances used the  $\chi^2$  test. Repeat or follow up EEGs were undertaken in about a quarter of subjects but these data have not been analysed in this report.

## Results

EEGs were recorded in 964 consecutive patients, aged 2 months to 17 years (mean 8 years). A total of 182 patients had had a single witnessed seizure; the remaining 782 patients had had at least two seizures. It was difficult to ascertain what proportion of these 782 patients had epilepsy as they were not all under the care of the authors and clinical information was therefore limited. However, at least 530 were considered to have epilepsy.

The records showed a continuous, persistent, or recurring focal abnormality in 157 patients (16%), of which 83 were slow waves and 74 were spike or sharp wave foci. Three of the 157 patients showed both a slow wave and epileptiform focus. CT head scans were performed in 121 of the 157 patients (77%) with an EEG focus. CT was not recommend-

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Table 1 Abnormal CT brain scan appearances associated with focal EEG abnormalities in 26 children

CT appearance	Focal EEG abnormality	
	Slow wave	Spike or sharp wave
Diffuse abnormality:		
Atrophy	3	
Ventricular dilatation		1
Tuberous sclerosis	1	
Localised abnormality:		
Focal atrophy (temporal lobe)	4	2
Hemiatrophy (one hemisphere)	3	1
Ventriculo peritoneal shunt	2	1
Infarct		2
Tumour (parietal lobe)	1	
Postsurgical (tumour resection)		1
Superior sagittal vein thrombosis		1
Sturge-Weber syndrome	1	
Bilateral agenesis, temporal lobes	1	
Encephalocele (frontal)	1	

ed for 19 patients who had clinical features and EEG findings typical of benign partial epilepsy with centro temporal (Rolandic) spikes; in the 17 other patients the referring physician felt CT to be unnecessary or the child failed to attend for the investigation.

CT findings were abnormal in 26 (21%) of the 121 patients in whom the investigation was undertaken. Abnormalities were seen in 17 (25%) patients with delta wave foci and in 9 (17%) patients with spike or sharp wave foci but this difference was not statistically significant. Twenty one (81%) of the abnormal scans showed a localised lesion (table 1). The most common abnormality was focal atrophy affecting either the temporal lobe or the whole hemisphere; this occurred in nine patients (7% of all scans). Generalised atrophy was found in three patients (2%). A tumour was detected in only one patient (0.08% of scans); on biopsy this proved to be a low grade astrocytoma.

Abnormal scans were more common in patients with recurrent seizures (both epileptic and non-epileptic) than in patients with a single seizure, but this difference was not statistically significant (table 2). There was a significantly larger number of abnormal scans in patients with partial (simple or complex) motor seizures and also in patients with focal neurological signs. In 10 of the 26 patients (39%) with an abnormal CT scan, the presence of an abnormality was predictable from focal neurological signs. No abnormal signs were found in the patient with the tumour, the patient with the encephalocele, or the six patients with temporal lobe atrophy. In all these categories there was no significant dif-

ference in the proportion of abnormal scans that occurred in patients with a slow wave focus compared with a spike or sharp wave focus on EEG.

## Discussion

The proportion of patients with seizures showing a focal abnormality on EEG—16%—is smaller than that found in previous studies: 47–66% for adults with epilepsy of mixed seizure type;<sup>5,11</sup> 31% for adults after a single seizure;<sup>7</sup> and 44–48% in children with epilepsy.<sup>8</sup> The present study was non-selective and included children who had experienced a single seizure (epileptic and non-epileptic) as well as children with epilepsy, and only focal EEG abnormalities that were persistent or recurrent and distinctly localised were included, which may account for the lower prevalence of focal abnormalities.

Studies of adults with seizures have found that 28–90% of delta wave foci and 40–60% of spike or sharp wave foci in the EEG were associated with abnormal CT scans (table 3). These figures are considerably higher than those in our study, although the proportion may have been greater if the 17 patients with non-Rolandic seizures who did not have a CT scan had undergone this investigation; however, this group represented only 10% of the population with focal EEG abnormalities and is therefore unlikely to have significantly altered the proportion of abnormal scans. The larger number of abnormal CT scans in adults with seizures has been attributed to the rising, and age related, incidence of generalised atrophy, tumours, and vascular lesions. The association between generalised cerebral atrophy and seizures in older patients may be spurious as the only controlled study found that the atrophy was equally prevalent in adults with epilepsy and controls.<sup>12</sup> In studies of children with seizures, 63% of patients with delta foci and 33–38% of patients with spike or sharp wave foci had abnormal scans,<sup>8,13</sup> which is higher than in the present study and similar to the results of adult studies. These paediatric studies may reasonably have been expected to find a higher prevalence of abnormal scans because the constituent patients had all been referred to a paediatric epilepsy clinic for intractable seizures or specifically for a CT scan.<sup>8</sup>

A total of 81% of abnormal CT scans in our study showed localised lesions, whereas earlier reports found that only 35–40% of CT lesions associated with EEG foci were localised.<sup>2,11,14</sup> The more common cerebral atrophy found in adults may partly explain the relatively lower proportion of abnormal scans showing focal lesions.

A considerable number of adults presenting with a first seizure have structural brain lesions: abnormal CT results have been reported in 37–47% of patients.<sup>7,10</sup> Only 8% of the children in our study with a single seizure had an abnormal scan. The probability of finding a localised or focal cerebral

Table 2 CT appearances associated with clinical features in children with focal EEG abnormalities

Clinical feature	CT scan appearance			No (%) of abnormal scans
	Normal	Diffuse abnormality	Localised abnormality	
All seizures (n = 121)	95	5	21	26 (21)
Single seizures (n = 25)	23	1	1	2 (8)
Epilepsy (n = 96)	72	4	20	24 (25)
Partial motor seizures (n = 39)	18	1	10	11 (38)*
Focal neurological signs (n = 16)	5	0	11	11 (68)†

\* $\chi^2 = 4.9$ ,  $p < 0.05$ .

† $\chi^2 = 21.2$ ,  $p < 0.001$ .

Table 3 Relation between abnormal head CT and EEG appearances in patients with seizures

Study	% of abnormal CT scans	Focal EEG abnormality (unspecified)	Focal delta wave	Focal spike or sharp wave	Diffuse EEG abnormality (+/- slow wave)
Bogdanoff <i>et al</i> (1975) <sup>1b</sup>	36		67		
Bachman <i>et al</i> (1976) <sup>8*</sup>	30	38		36	
Scollo-Lavizzari <i>et al</i> (1977) <sup>17</sup>	34		90		
Yang <i>et al</i> (1979) <sup>13*</sup>	33		63	33	
Bauer <i>et al</i> (1980) <sup>2</sup>	54	58			40
Ladurner <i>et al</i> (1980) <sup>14*</sup>	42	47			
Scollo-Lavizzari <i>et al</i> (1980) <sup>16</sup>	33		76	46	19†
Young <i>et al</i> (1982) <sup>3</sup>	24		28		
Ramirez-Lassepas <i>et al</i> (1984) <sup>10</sup>	37	72			20
Lopez <i>et al</i> (1985) <sup>11</sup>	51	52	58	40	
Reinikainen <i>et al</i> (1987) <sup>5</sup>	36		38	40	11‡; 33 <sup>c</sup>
Present study (1992) <sup>*</sup>	26		25	17	

\*Exclusively children.

†Diffuse spike or sharp waves.

<sup>c</sup>Diffuse slow waves.

lesion was increased in our patients with partial motor seizures and was even more likely in the presence of focal neurological signs, as reported previously.<sup>2,3,6,11,13</sup> However, there is no entirely reliable combination of clinical features or EEG findings that always predicts finding a structural lesion. In adults with seizures due to tumours, 20% have a normal EEG and 40–60% have normal neurological findings.<sup>11,15</sup>

One of the primary aims in undertaking head CT in patients with epilepsy is to identify an aetiology that may be amenable to surgical treatment. The proportion of patients with seizures found an CT to require surgical intervention varies from 1–2% in children<sup>8,13</sup> to 6–10% in adults.<sup>3,16</sup> In our study the information gained from CT altered the management of only two out of 21 patients with localised abnormalities directed on CT (1.7% of all scans): one patient had a parietal astrocytoma, the other a frontal encephalocoele. Both experienced repeated and drug resistant partial seizures but neither had focal neurological signs. Brain tumours in children are more commonly sited infratentorially and present with symptoms and signs of raised intracranial pressure or cranial nerve dysfunction, or both, rather than with epileptic seizures; EEGs are therefore rarely performed. This may explain the low incidence of tumours in our study. The number of patients with localised cerebral lesions (including tumours or abnormalities of neuronal migration) in whom surgical treatment is indicated is likely to increase with the development of improved imaging and surgical techniques.

Epilepsy is a common disorder, and over one half of patients develop seizures before the age of 16 years. Head CT is often requested in this age group to reassure both the family and the clinician. Such reassurance may, however, occasionally be misplaced; an initial scan could be normal, and only after months or years may subsequent CT scans reveal a glioma or other tumour.<sup>3</sup> CT scanning in young children may be difficult; it often requires sedation and occasionally general anaesthesia, and it involves some (albeit minimal) ocular irradiation. There is no justification for scanning all children with epileptic seizures, and even the presence of a focal abnormality on the EEG is not necessarily a prerequisite for CT, as shown in this study.

Each CT investigation should be undertaken on the basis of the clinical history and examination and is clearly indicated in patients with epilepsy who have intractable partial seizures or lateralising neurological findings or both. In this group positive findings on CT are often important and helpful in counselling the family, irrespective of possible surgical intervention.

Finally, our results suggest that no distinction should be made between a delta (slow) wave or spike or sharp wave focus, if a focal abnormality on EEG is included as one of the criteria for undertaking CT. The yield of abnormal CT scans in children with an EEG focus will be lower than in adults, and very low after just one seizure.

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