PERSONAL PRACTICE

The EEG and neuroimaging in the management of the epilepsies

N V O'Donohoe

The following two papers are the beginning of an occasional series where we have asked two eminent experts to tackle the same clinical problem. Professor Niall O'Donohoe and Dr Christopher Verity have approached the subject in different ways.

Editors

Diagnosis

Lennox wrote that 'every fresh case of epilepsy is an undiagnosed one'.¹ Epilepsy is a recurring disorder of brain function in which seizures, which may be convulsive or non-convulsive, partial or generalised, are the presenting symptoms. The diagnostic pathway from the complaint of seizures to the verification of epilepsy may be a difficult one. It is essential that misdiagnosis be avoided, recognising that by no means all children with paroxysmal events, spells, or 'funny turns' are suffering from epilepsy.^{2,3}

Apart from the need of a correct diagnosis, the other important diagnostic considerations are seizure diagnosis, that is categorisation of the type or types of seizures occurring; aetiological diagnosis, recognising that it is now possible to identify pathological, genetic, and biochemical abnormalities in a growing number of cases; and syndrome diagnosis, which consists of the identification of a particular epileptic syndrome, if one can be delineated.⁴ The cornerstones of diagnosis in all instances reside, as they have always done, in careful history taking and physical examination.⁵ One might add that the widespread availability of the hand held camcorder provides us with a new and convenient method for recording clinical seizures on videotape, either at home or in the clinic.

Diagnostic role of the EEG

The electroencephalogram (EEG) remains the single most valuable aid to the clinical diagnosis of epilepsy, a diagnosis for which it may offer support but one which it will not necessarily exclude. It is likely that the EEG will retain a permanent place in the everyday measurement of brain function. EEG examinations are painless, usually of short duration, widely available, and relatively inexpensive. Interictal epileptiform discharges are generally more frequently seen in infantile and childhood epilepsy than in adult forms.⁶ There are, however, considerable differences in paediatric EEGs, as compared with adult tracings, and evolving changes in the EEG, both in the waking state and during sleep, occur from infancy through early childhood and into late childhood.⁷ The interpretation of paediatric EEGs requires special knowledge and experience on the part of the

examiner and should preferably be done by one well versed in the problems of neuropaediatrics. It is recommended that EEG departments specifically for children are essential as also, indeed, are EEG technicians familiar with the everyday problems of obtaining good and reliable recordings in children.⁸

The EEG in the classification and management of epilepsy

In addition to its value as a diagnostic aid, the EEG may:

- Help in classifying the epilepsies
- Suggest an aetiology
- Guide clinical management (choice of drugs, assessment of response to treatment, decisions about stopping treatment)
- Provide evidence of localisation when epilepsy surgery is contemplated.

The epilepsies and epileptic syndromes

The epilepsies are classified in two ways. First, a distinction is made between the generalised epilepsies, in which seizures apparently arise simultaneously in both hemispheres, and partial (or localisation related) epilepsies, in which seizure onset is confined to a discrete region of cortex. The second dichotomy distinguishes primary or idiopathic epilepsies arising in a structurally normal brain from secondary or symptomatic epilepsies arising in patients with structural brain disease and cryptogenic epilepsies caused by presumed but unproved pathology.⁹

Various specific brain syndromes are now recognised within the general framework of the epilepsies.¹⁰ Many of these have distinct clinical features, treatment, and prognosis. Primary epileptic syndromes with no demonstrable pathology, in which the seizures constitute the disease, are distinguished from secondary or symptomatic epileptic syndromes, in which the seizures draw attention to the existence of an underlying neurological disorder. The primary syndromes are usually age related, have a strong genetic component, and often respond well to treatment with a good possibility of permanent remission. The secondary syndromes include other evidence of brain dysfunction and response to treatment and prognosis are uncertain.

Department of
Paediatrics, Trinity
College, Dublin

Correspondence to:
Professor N V O'Donohoe,
43 Orwell Park, Rathgar,
Dublin 6, Ireland.

The EEG and the classification of the epilepsies

Seizures, either generalised or partial, are the clinical events which draw attention to the existence of various epilepsies and epileptic syndromes. The EEG can be extremely valuable in making a precise diagnosis of the type of epilepsy that is present. In primary or idiopathic generalised epilepsies, both ictal and interictal discharges are generalised. The classical 3 Hz spike-wave discharges seen interictally and during the absences of childhood absence epilepsy (true petit mal) are typical and represent the electrographic marker of the inherited predisposition to epilepsy. Equally important in such an EEG is the presence of a normal background activity. Symptomatic generalised epilepsies, on the other hand, usually show a diffuse abnormality of the background rhythm, reflecting the generalised cerebral pathology, and interictal and ictal discharges are of varied morphology.

In primary partial epilepsies as, for example, in the common benign partial epilepsy with centrottemporal (rolandic) spike discharges, the location and morphology of the spikes are usually typical and, again, the background activity is normal. Symptomatic partial epilepsies are characterised by the presence of focal discharges, both at seizure onset and in the interictal state. Secondary generalisation of such discharges may occur and there are usually other associated abnormalities such as focal slowing and disorganisation of the background rhythm.^{6,8} It is of crucial diagnostic importance to differentiate the rolandic spike discharges seen in benign partial epilepsy of childhood from those discharges which arise deep in the temporal lobes in children presenting with complex partial seizures. The latter are propagated to the anterior or mid-temporal areas without suprasylvian extension. The clinical presentations are, of course, quite different in the two epilepsies. Curiously, however, sleep is a potent activator of both types of discharge and it should be remembered that the waking record may not reveal discharges in either epilepsy. In fact, sleep is the single most important activating procedure available for use during everyday EEG recordings. It should be utilised as much as possible in the evaluation of suspected epilepsy, especially when interictal epileptiform activity is not well defined or even absent in the waking record. All night sleep recordings are valuable in some cases and may help to differentiate complex partial seizures arising from the frontal lobes, often misdiagnosed as non-epileptic sleep disorders.¹¹ Sleep deprivation, before a daytime EEG, can enhance the possibility of obtaining spontaneous sleep during the recording.

The EEG and aetiological diagnosis

Exact aetiological diagnosis remains difficult in the epilepsies, despite great advances in the understanding of their physiological and molecular basis.¹² Nevertheless, as aetiology has important implications for higher cortical

function in epilepsy, influences the natural history and the response to treatment of the disorder, and is closely linked to outcome and the possibility of remission, it should be carefully considered in each case. The EEG is of value for identifying particular epileptic syndromes (for example infantile spasms, Lennox-Gastaut syndrome) with consequent implications for management and prognosis. Specific EEG patterns of abnormality are seen in subacute sclerosing panencephalitis,¹³ Batten's disease,¹⁴ lissencephaly,¹⁵ and the happy puppet syndrome of Angelman,¹⁶ in all of which clinical epilepsy may occur.

The EEG and clinical management: choice of drugs

The EEG can assist in the choice of drugs for treating particular epilepsies but only to a very limited extent. Perhaps only in childhood absence epilepsy with classical 3 Hz spike-wave discharges does the EEG dictate the use of ethosuximide or sodium valproate or now, in resistant cases, a trial of lamotrigine.¹⁷ Contrariwise, typical or atypical spike-wave patterns in children with other types of absence seizure may prohibit the use of carbamazepine which can cause an exacerbation of epilepsy in these seizure disorders.¹⁸

Ongoing management

The EEG is of limited value as a reflection of clinical improvement in epilepsy, except perhaps in some of the primary generalised epilepsies, where clinical and EEG improvement may coincide. In the most common epileptic syndrome of schoolchildren (benign partial epilepsy with centrottemporal spikes), the frequency of the discharge bears no relationship to the severity or otherwise of the clinical epilepsy and EEG discharges may persist long after clinical remission has occurred. Furthermore, there is considerable diurnal and nocturnal variability in the EEG and a 30 minute recording provides only a brief window depicting the physiological state of the brain at that time.⁸ The widespread misconception that the EEG will provide the clinician with information about the state of the patient's epilepsy leads to unnecessary requests for repeat EEG examinations, thereby adding to the burdens of EEG departments. Neither annual nor other periodic 'routine' EEGs add much to patient assessment, which should remain predominantly a clinical exercise. However, if there has been a clear cut recent deterioration in the clinical state, and this is particularly true of a chronic epilepsy, evidence of associated marked deterioration in the EEG may point to the need for a thorough review of the case and its management and perhaps the need for additional investigations.

Withdrawing treatment

Clinical considerations should also determine decisions about withdrawing medication and these should include knowledge about the

natural history of the particular epilepsy and the possibility of remission. There is an unquestionable correlation between individual epileptic syndromes and the success or failure of drug treatment. Primary generalised epilepsies do best while those epilepsies characterised by secondary partial seizures, particularly complex partial seizures, and cases with multiple seizure types, fare worst. In some syndromes, the EEG remains abnormal long after clinical remission has occurred. The example of benign partial epilepsy with centrottemporal spikes has been given. On the other hand, a normal EEG during treatment of juvenile myoclonic epilepsy, in which the propensity to seizures and the consequent need for antiepileptic drugs are life long, should not be used as an argument for stopping treatment.⁵

Nevertheless, despite these clinical considerations and caveats, the EEG can be a valuable additional aid when deciding how and when to withdraw treatment, especially in difficult cases.¹⁹ Two definitive studies of the outcome of childhood epilepsy, separated by an interval of 12 years,^{20 21} both found that, in general, the otherwise normal child who had had a limited number of seizures and whose EEG was normal or only mildly abnormal was least likely to relapse when treatment was stopped.

Contemplating epilepsy surgery

Epilepsy surgery is being considered more often in children and adolescents with medically intractable seizures. Presurgical evaluation of such cases is necessarily very detailed. In children who may require temporal lobe resection because of intractable complex partial seizures, the non-invasive recording of ictal events using simultaneous EEG and video monitoring remains the most important pre-operative investigation.²² Invasive depth EEG recordings using bilateral sphenoidal electrodes may additionally be necessary and can be of invaluable assistance in identifying deep seated mesial temporal epileptogenic foci.

Febrile convulsions

Paediatricians often are uncertain about the role of the EEG in the management of the child with febrile convulsions. In the writer's opinion, there is no benefit from routine EEG examination in such children. A history to establish the diagnosis, a physical examination to find the source of fever and to exclude meningitis, and a lumbar puncture if there is doubt about meningitis and especially in infants under 1 year, are the only measures that should regularly be undertaken after most febrile seizures.^{23 24} The EEG is not a guide to treatment or prognosis and should certainly not be undertaken after the initial convulsion. Bilateral slow wave changes will usually be present after the majority of attacks and will persist for some days. Focal or asymmetrical slowing may be found after more prolonged seizures. Reversion of the EEG to normal is the rule. A problem arises in children with repeated febrile convulsions and in whom

reassurance for parents may be an issue. Again, the record will nearly always be normal or may occasionally show spike-wave paroxysms, particularly in rather older children during drowsiness. This latter finding should be regarded as an expression of a genetic predisposition to epilepsy and certainly not as an indication that epilepsy will develop in an individual patient.⁵ However, it should be remembered that seizures are sometimes provoked by fever in children who have genuine epilepsy. In these, the EEG will usually show unequivocal and frequent epileptic abnormalities.

EEG abnormalities in normal children

It is important that paediatricians should be aware that epileptiform discharges may be found in about 3% of normal children^{7 25} and in up to a quarter of healthy siblings of children with benign partial epilepsy. These discharges are similar to those which occur in benign partial epilepsy, are predominantly mid-temporal and centrottemporal in situation, and vary in intensity and location from time to time, including moving from side to side. Unfortunately, a folklore has grown up over many years in connection with these fortuitous findings and terms such as 'masked epilepsy' and 'epileptic equivalents' have been used. Children with a variety of non-epileptic complaints such as behaviour problems, syncopal episodes, night terrors, headache, abdominal pain, tics, so-called minimal brain damage, specific or general (including attentional) learning difficulties, etc, have been subjected to unnecessary antiepileptic medication and their parents made anxious about possible epilepsy.² Using the EEG to decide whether a patient's symptoms are epileptic or psychogenic or due to some non-cerebral cause such as syncope is an improper use of the investigation and can be misleading. A single normal EEG is not evidence against epilepsy nor is the finding of epileptiform discharges in the EEG evidence that the patient's symptoms are necessarily epileptic in nature. The recognition of the epileptic nature of any symptoms or group of symptoms is a clinical task predominantly and should remain so.²⁶

Advent of neuroimaging

During the past 25 years, the advent of neuroimaging techniques has revolutionised neurology, neuroradiology, and neurosurgery. In the evaluation and management of epilepsy, computed tomography and magnetic resonance imaging (MRI) now complement the electrophysiological information provided in the EEG by identifying structural brain disease which may be causally related to the development of seizures. At present, computed tomography is much more widely available and also less expensive than MRI and this situation is unlikely to change in the immediate future.

Computed tomography and epilepsy

A relatively early computed tomography study of children with all types of seizures revealed

an overall incidence of abnormalities in a third of cases.²⁷ The presence of an abnormal neurological examination in any case doubled the likelihood of finding an abnormality on computed tomography brain scan. Abnormalities were demonstrated most frequently in patients with secondary partial seizures and with secondary generalised seizures but were rarely seen in children with partial or generalised seizures of primary type. In a more recent study, at a north of England special school for children with epilepsy (and therefore a selected group with chronic epilepsy and with associated handicaps in a proportion), an overall incidence of abnormalities on computed tomography was again found in a third of cases.²⁸ The usual abnormality detected was some degree of generalised or focal cortical atrophy.

MRI and epilepsy

Among the several advantages of MRI compared with computed tomography are higher sensitivity, superior image quality, lack of radiation exposure, and a capacity for multiplanar display. Visualisation of central nervous system anatomy has been revolutionised by MRI because it enables fine detail of the brain to be displayed and is capable of defining subtle abnormalities of the cortical grey matter and hippocampus which are not visible on computed tomography.²⁹ Rapid advances in MRI techniques have led especially to improvements in the detection of brain lesions in patients with epilepsy.³⁰ New insights into the aetiology of the epilepsies have been gained and there have even been discoveries of new syndromes characterised by epilepsy associated with mental handicap and developmental abnormalities of the brain.³¹ MRI is superior to computed tomography in identifying abnormalities of cortical architecture, especially those resulting from neuronal migration disorders, for detecting gliomas and vascular malformations, and in visualising the temporal lobe structures.³² The information provided by MRI is extremely important both for the recognition of these disorders and for the planning of appropriate medical and surgical treatment.

MRI scanning in the paediatric patient has the disadvantage, however, that sedation or even a general anaesthetic may be required to ensure the degree of immobility necessary in order to obtain clear interpretable images. Furthermore, as in the early years of computed tomography, considerable experience is required in the methodology and interpretation of paediatric MRI and the advice of a neuroradiologist with a special interest in that subject may be essential.

MRI and temporal lobe epilepsy

Epilepsy originating from the temporal lobes is the most important secondary partial epilepsy of childhood and may cause complex partial seizures to occur even from very earliest childhood. The causative lesions are situated deep in one or other temporal lobe.³³

Developmental abnormalities including neuronal migration disorders, vascular and neoplastic conditions, and, most importantly, hippocampal sclerosis (mesial temporal sclerosis) are the main lesions found. MRI is much more sensitive to the localisation and lateralisation of these lesions than are either conventional scalp EEG or computed tomography scanning.³⁴ This has important implications for the management of this most disabling and chronic form of epilepsy as precise identification and early surgical removal of the offending lesion may cure the epilepsy and also help to prevent the psychiatric, social, and cognitive morbidity of severe uncontrolled epilepsy in childhood.⁵

Functional neuroimaging

The EEG is helpful in diagnosis but is poor at localising functional changes in epilepsy. Computed tomography and MRI provide only structural information. Functional neuroimaging techniques can provide information about regional metabolic activity in the brain. Positron emission tomography (PET) is largely a research tool. Single photon emission tomography (SPECT) uses a gamma camera and is less expensive than PET and more widely available. Both techniques show metabolism and perfusion in the epileptogenic focus to be decreased interictally and ictally increased and many help to localise a focus which is not visible on MRI.³⁵ The recent development of non-invasive functional MRI methods is most exciting as they are capable not only of demonstrating the structure of the brain in fine detail, but also of providing information about the underlying metabolism of brain regions and of revealing the functional activity of the brain with high spatial and temporal resolution.³⁶ They are already being used to study cryptogenic generalised epileptic syndromes such as infantile spasms and Lennox-Gastaut syndrome in an attempt to locate areas of focal dysfunction which may be amenable to surgical removal. It is important to emphasise that these functional images do not make sense by themselves but only do so in the context of the whole clinical, EEG, neuropsychological, and neuroradiological information about the child.

Indications for neuroimaging

What should the paediatrician regard as indications for neuroimaging when dealing with the problem of an individual child's epilepsy (for most paediatricians, this will mean computed tomography, at least in the first instance)? The following are the main indications:

- Partial seizures (in all children), except those with benign partial epilepsy
- Abnormal neurological signs
- Persistent and localised slow wave changes (delta focus) and/or spike or sharp wave foci, either or both of which may indicate the presence of a local structural lesion^{27 37}

- Manifestation of a sudden change in seizure pattern, in neurological examination, or in the EEG (any or all of which may indicate the presence of a progressive lesion).

Patients with refractory seizures, even of many years' duration, should be considered as candidates for imaging, particularly MRI if available, because of the possible presence of a potentially resectable epileptogenic lesion. Indolent gliomas, for example, may be an occult cause of chronic epilepsy.³⁸ There is increasing recognition of the importance of embryofetal lesions, especially neuronal migration disorders, in children with moderate or severe mental handicap and epilepsy.³² Lissencephaly (agyria-pachygyria), for example, may be suspected by the presence of excessive high amplitude fast activity in the EEG and a computed tomography scan will show the typical smooth appearance of the cortex.¹⁵ The importance of searching for the brain lesions of tuberose sclerosis by computed tomography in the severe epilepsies of infancy and early childhood is well known.³⁹

Epilepsy is a common disorder, beginning most frequently during childhood and adolescence, and one which causes great parental worry. It is not surprising, therefore, that a computed tomography brain scan is often requested for parental reassurance in the face of marked and continuing anxiety. It should be pointed out to the family, however, that computed tomography in young children can be difficult and may require sedation or even anaesthesia. It also involves a minimal amount of ocular irradiation. Furthermore, the reassurance provided by a normal computed tomography is not absolute as subsequent scans months or years later may reveal a lesion such as a glioma or other tumour.³⁸ There is simply no justification for scanning all children with epilepsy and the investigation should be undertaken primarily on the basis of clinical history and examination.³⁷

Medicolegal problems

The rising tide of medicolegal litigation alleging negligence by doctors has inevitably led to the practice of defensive medicine. This has meant the overuse of investigation in order to prevent, at a later date, allegations of negligence because of failure to perform a particular test or radiological procedure. For paediatricians negligence means that they have failed to fulfil their duty of care to the child. To succeed in such a claim, the parents need to show that their child is damaged, they have to demonstrate the cause of that damage and then prove, on the balance of probabilities, that the damage was due to the negligence of the doctors.⁴⁰

A relevant dilemma for paediatricians in this context is whether to choose a computed tomography or MRI scan when evaluating a child with seizures. Although MRI is technically superior to computed tomography, its current cost, lack of availability, and the fact that it is lengthy and rather frightening procedure for a child, prohibit its use as a 'screening' procedure, even if one accepts that it is

reasonable to screen for every eventuality. Paediatricians investigating a child with epilepsy may be anxious about missing a progressive and potentially treatable lesion such as a neoplasm. In fact, neoplasms are relatively rare causes of childhood epilepsy as most arise subtentorially and are non-epileptogenic. Nevertheless, deep seated temporal lobe tumours can cause intractable complex partial seizures³³ and such tumours may be revealed by MRI, although invisible on computed tomography. If, therefore, the paediatrician remains concerned about the presence of a tumour or other structural lesion after a normal computed tomogram in a child with complex partial seizures, MRI should be obtained. MRI should also be requested when there are equivocal lesions on computed tomography. Attention has already been drawn to the importance of considering patients with refractory seizures for MRI, if available, because of the possible existence of a lesion which may be surgically treatable. Infants with unexplained seizures should be considered for computed tomography, especially if there is a suspicion of non-accidental trauma, as subdural haematoma not infrequently presents in this manner.⁴¹

In conclusion, it must be emphasised that the surest means of avoiding error and also the accusation of not having 'done everything' is one which applies to the investigation and management of childhood epilepsy in general, that is, meticulous clinical assessment and regular review of the problem. Only thus can unnecessary and expensive investigative procedures be kept to a minimum.

- 1 Lennox WG. *Epilepsy and related disorders*. Vols 1, 2. London: J and A Churchill, 1960.
- 2 Stephenson JBP. *Fits and faints. Clinics in developmental medicine*. No 109. Oxford: Blackwell Scientific Publications, 1990.
- 3 Brett EM. 'It isn't epilepsy is it, doctor?' *BMJ* 1990; 300: 1604-5.
- 4 O'Donohoe NV. Delineation of epileptic syndromes. *Current Paediatrics* 1992; 2: 68-72.
- 5 O'Donohoe NV. *Epilepsies of childhood*. 3rd Ed. London: Butterworth-Heinemann, 1994.
- 6 Drury I. Epileptiform patterns of children. *J Clin Neurophysiol* 1989; 6: 1-39.
- 7 Peterson I, Eeg-Olofsson O. The development of the electroencephalogram in normal children from the age of 1 through 15 years. Non-paroxysmal activity. *Neuropädiatrie* 1971; 2: 247-304.
- 8 Binnie CD. Neurophysiological investigations of epilepsy in children. In: Ross EM, Woody RC, eds. *Epilepsy. Baillière's clinical paediatrics. International practice and research*. Vol 2. No 3. London: Baillière Tindall, 1994: 585-604.
- 9 O'Donohoe NV. Classification of epilepsies in infancy, childhood and adolescence. In: Ross EM, Woody RC, eds. *Epilepsy. Baillière's clinical paediatrics. International practice and research*. Vol 2, No 3. London: Baillière Tindall, 1994: 471-84.
- 10 Roger J, Bureau M, Dravet C, Driefuss FE, Perret A, Wolf P. *Epileptic syndromes in infancy, childhood and adolescence*. 2nd Ed. London, Paris: John Libbey, 1992.
- 11 Stores G. Confusions concerning sleep disorders and the epilepsies in children and adolescents. *Br J Psychiatry* 1991; 158: 1-7.
- 12 Schwartzkroin PA, ed. *Epilepsy. Models, mechanisms and concepts*. Cambridge: Cambridge University Press, 1993.
- 13 Ibrahim MM, Jeavons PM. The value of electroencephalography in the diagnosis of subacute sclerosing panencephalitis. *Dev Med Child Neurol* 1974; 16: 295-307.
- 14 Pampiglione G, Harden A. So-called neuronal ceroid lipofuscinosis. Neurophysiological studies of 60 children. *J Neurol Neurosurg Psychiatry* 1977; 40: 323-30.
- 15 Gastaut H, Pinsard N, Raynaud C, Aicardi J, Zifkin B. Lissencephaly (agyria-pachygyria). Clinical findings and serial EEG studies. *Dev Med Child Neurol* 1987; 29: 167-80.
- 16 Boyd SG, Harden A, Patton MA. The EEG in early diagnosis of Angelman's (happy puppet) syndrome. *Eur J Pediatr* 1988; 147: 503-13.

- 17 Besag FMC. Difficult-to-treat childhood epilepsies. In: Reynolds EH, ed. *Lamotrigine – a new advance in the treatment of epilepsy*. London: Royal Society of Medicine Services, 1993: 53–64.
- 18 Snead OC, Hosey LC. Exacerbation of seizures in children by carbamazepine. *N Engl J Med* 1985; 313: 916–21.
- 19 Shinnar S, Berg AT, Moshé SL, et al. Discontinuing antiepileptic drugs in children with epilepsy: a prospective study. *Ann Neurol* 1994; 35: 534–45.
- 20 Emerson E, D'Souza BJ, Vining EP, Holden KR, Mellits ED, Freeman JM. Stopping medication in children with epilepsy. Predictors of outcome. *N Engl J Med* 1981; 304: 1125–9.
- 21 Camfield C, Camfield P, Gordon K, Smith P, Dooley J. Outcome of childhood epilepsy. A population-based study with a simple predictive scoring system for those treated with medication. *J Pediatr* 1993; 122: 861–8.
- 22 Holmes GL. Surgery for intractable seizures in infancy and early childhood. *Neurology* 1993; 43 (suppl 5): S28–37.
- 23 Joint Working Group of the Royal College of Physicians and the British Paediatric Association. Guidelines for the management of convulsions with fever. *BMJ* 1991; 303: 634–6.
- 24 Camfield PR, Camfield CS. Febrile seizures. In: Ross EM, Woody RC, eds. *Epilepsy. Baillière's clinical paediatrics. International practice and research*. Vol 2, No 3. London: Baillière Tindall, 1994: 547–59.
- 25 Cavazzuti GB, Capella L, Nalin A. Longitudinal study of epileptiform EEG patterns in normal children. *Epilepsia* 1980; 21: 43–55.
- 26 Lerman P, Kivity S. Focal epileptic EEG discharges in children not suffering from clinical epilepsy. In: Degan R, Dreifuss FE, eds. *Benign localized and generalized epilepsies of early childhood*. Amsterdam, London: Elsevier, 1992: 99–103.
- 27 Yang PJ, Berger PE, Cohen ME, Duffner PK. Computed tomography and childhood seizure disorders. *Neurology* 1979; 29: 1084–8.
- 28 Gordon N. Computed tomography in childhood epilepsy. *Arch Dis Child* 1988; 63: 1114.
- 29 Barnes PD. Imaging of the central nervous system in pediatrics and adolescence. *Pediatr Clin North Am* 1992; 39: 743–76.
- 30 Anonymous. Magnetic resonance imaging in epilepsy [Editorial]. *Lancet* 1992; 340: 343–4.
- 31 Kuzniecky R, Andermann F, Guerrini R, and the Congenital Bilateral Perisylvian Syndrome (CBPS) Multicenter Collaborative Study. Congenital bilateral perisylvian syndrome: study of 31 patients. *Lancet* 1993; 341: 608–12.
- 32 Kuzniecky R. Magnetic resonance imaging in developmental disorders of the cerebral cortex. *Epilepsia* 1994; 35 (suppl 6): S44–56.
- 33 Wyllie E, Lüders H. Complex partial seizures in children: clinical manifestations and identification of surgical candidates. *Cleve Clin J Med* 1989; 56 (suppl (pediatric epileptology) part I): S43–52.
- 34 Cross JH, Jackson GD, Neville BGR, et al. Early detection of abnormalities in partial epilepsy using magnetic resonance. *Arch Dis Child* 1993; 69: 104–9.
- 35 Anonymous. SPECT and PET in epilepsy [Editorial]. *Lancet* 1989; 333: 135–7.
- 36 Jackson GD. New techniques in magnetic resonance and epilepsy. *Epilepsia* 1994; 35 (suppl 6): S2–13.
- 37 Gibbs J, Appleton RE, Carty H, Beirne M, Acomb BA. Focal electroencephalographic abnormalities and computerised tomographic findings in children with seizures. *J Neurol Neurosurg Psychiatry* 1993; 56: 369–71.
- 38 Lee TKY, Nakasa Y, Jeffree MA, Molyneux AJ, Adams CBT. Indolent glioma: a cause of epilepsy. *Arch Dis Child* 1989; 64: 1666–71.
- 39 Riikonen R, Simell O. Tuberose sclerosis and infantile spasms. *Dev Med Child Neurol* 1990; 32: 203–9.
- 40 Hull D. A question of negligence. *Current Paediatrics* 1993; 3: 52–5.
- 41 Aoki N. Chronic subdural haematoma in infancy: clinical analysis of 30 cases in the CT era. *J Neurosurg* 1990; 73: 201–5.

The place of the EEG and imaging in the management of seizures

C M Verity

'Most diagnostic investigations are open to abuse, but none more so than the EEG'. (Binnie 1994.¹)

'There is considerable debate in the literature about whether all patients with seizures require CT scans.' (Holmes 1989.²)

This paper discusses the choice of appropriate investigations for children with seizures and takes the form of a series of questions for which answers are suggested. The word *seizure* is used rather than *fit* and the term *febrile convulsion* rather than *febrile seizure*. *Epilepsy* is defined as recurrent (more than one) afebrile seizures.

General considerations

WHAT TYPES OF SEIZURE OCCUR IN CHILDHOOD AND WHY DOES IT MATTER?

When considering a general approach to children with seizures it helps to know the frequency of seizure types in the population. The table shows some of the findings of the Child Health and Education Study, which followed up a national cohort of children for the first 10 years of life.^{3 4} Some of the important observations were as follows: febrile convulsions were relatively common – they affected 2.7% of children. The majority were simple febrile

convulsions, but 22% were complex (that is longer than 15 minutes' duration, focal or multiple during one episode of fever). Afebrile seizures were much less common – about 0.4% of children in the study had epilepsy. The commonest afebrile seizure type was tonic-clonic, but complex partial seizures were the next and classical childhood absence seizures ('petit mal') were the least common of all (just one child in the cohort).

The cause of seizures and the prognosis varies with the seizure type. When considering appropriate investigations for the individual child it makes sense to consider which seizure types occur most commonly – children with 'blank spells' are more likely to be having complex partial seizures or atypical absences than true 'petit mal' (see the table).

WHEN SHOULD INVESTIGATIONS BE PERFORMED?

Not too soon. *The most important step is to obtain a good history*. The parents may be able to record attacks at home using their own video.⁵ The diagnosis of epilepsy is clinical and should not be made without 'incontrovertible clinical evidence'.⁶ Such evidence is usually provided by the patient's description and by