Seminar on Epilepsy in Children—continued

ELECTROENCEPHALOGRAPHY

CLIFFORD TETLOW, M.D., B.Sc., D.P.M.

Psychiatrist, The Central Hospital, Nr. Warwick

CHILDREN make good subjects for electroencephalography, and even infants can be readily investigated by using stick-on electrodes. A good deal naturally depends on the patience and understanding of the recordist, but it is not uncommon for infants to be so unconcerned by the electrodes as to fall asleep during the recording, a sleep record in itself being a useful addition to the investigation.

Out of a recent consecutive series of 60 cases of clinical epilepsy in children 43 or 72% were confirmed by unmistakable electrical abnormalities, many of them at a first recording. Since epilepsy is a clinical diagnosis, a normal electroencephalogram or even several cannot exclude such a diagnosis, but it is surprising how many requests are received by electroencephalography departments 'to exclude epilepsy'. In this connection the importance of serial recordings, both in diagnosis and in clinical progress, needs to be stressed, as pointed out by Hill (1963).

Instability of the Child's Electroencephalogram

There are several reasons why electrical abnormalities readily show in epileptic children, in contrast to adults, where many recordings may be needed before an abnormality can be demonstrated. One reason is that the child's skull offers less resistance to the electrical current making the recording easier technically, but more important is the probability that electrical control systems safeguarding against paroxysmal or focal discharge are less well developed. Thus febrile convulsions are common in children but do not occur in adults, and in most of these children subsequent encephalograms are normal. Similarly Baird and Garfunnel (1956) have shown that artificially induced hyperthermia produces temporary changes in the child's encephalogram.

A minority of febrile convulsions, particularly those associated with focal clinical signs, may show persisting electrical focal abnormalities. Also, febrile convulsions associated with brain infections will show persisting electrical abnormalities, and Nyman (1954) has demonstrated persistent electrical abnormalities in a few cases of acute rheumatism.

Homeostasis

Warm-blooded animals to some extent carry their own environment around with them and maintain their central nervous systems at a relatively constant physical and chemical state—a concept known as homeostasis, which is preserved by elaborate hormonal and other feedback mechanisms, as is well known.

Homeostasis is less complete in children, and electrical abnormalities readily show if the cerebral environment is altered, a principle which is used to uncover potential electrical abnormalities in the so-called provocation techniques which are employed in electroencephalography. Thus overbreathing for three minutes, thereby washing out carbon dioxide and therefore altering the hydrogen ion concentration of the blood, is a routine procedure. Though it produces little effect in normal adults, a marked change occurs in the child's encephalogram (Figs. 1 and 2).

Overbreathing can be used incidentally as a clinical test in suspected cases of petit mal epilepsy, where it may readily provoke an attack.

Similarly fasting, by reducing the blood sugar level, brings about changes in the electroencephalogram, and may help to reveal potential abnormalities. If a straight recording from an epileptic child shows no abnormality, it is often rewarding to repeat it with the child fasting.

Photic Stimulation

Complex electronic apparatus can become overloaded, similarly stroboscopic stimulation of a subject in a darkened room at frequencies approaching those of the electroencephalogram can modify the basic electrical pattern in most subjects. Pantelakis, Bower and Jones (1962) maintain that a specific 'photo-convulsive' response is almost confined in children to those with a history of fits. This response is a generalized one (Fig. 3) and not one restricted to the occipital region, which can sometimes occur in normal children and adults (Fig. 4). Persistent photic stimulation in a susceptible individual will, of course, produce a fit, so discretion must be exercised by the recordist in using this type of provocation, which it is in any case unwise to

FIG. 1.—Normal child aged 4 years. Resting record.

FIG. 2.—The same child as Fig. 1 but taken whilst overbreathing. Shows high amplitude slow waves of 4 c/s.

FIG. 3.—Child age 11 years, subject to epileptic fits whilst watching television. Photo-convulsive responses shown initiated by a flicker frequency of about 14 c/s.

FIG. 4.—Normal adult age 32 years showing response to photic stimulation, but only in the posterior leads. A normal response.

FIG. 5.—Natural sleep record in an infant age 17 months. Shows a 'K' complex which is a normal response to afferent stimulation whilst asleep, and easily mistaken for epileptic discharge. It is immediately followed by 16 c/s activity known as 'sleep spindles'.

FIG. 6.—Child age 9 years suffering from primary subcortical epilepsy. Shows bilaterally synchronous wave and spike activity. His attacks were of 'Petit Mal' type, but 'Grand Mal' attacks can occur with this type of discharge, though no aura is experienced.

FIG. 7.—Focal Epilepsy. Child age 10 years showing a left tempo: a' focus.

FIG. 8.—The same child as in Fig. 7, but this record is taken five years later when the focus could no longer be demonstrated. He is free from fits, though still on medication.

FIG. 9.—Child age 10 years suffering from focal epilepsy. Shows right posterior temporal focus, which could only be demonstrated during induced barbiturate sleep.

FIG. 10.—Natural sleep record in a child age 5 years suffering from focal fits. Shows left anterior temporal focus, and also greatly diminished sleep spindle activity in the same area of cortex.

FIG. 11.—Child age 6 years presenting with febrile convulsions, but the tracing shows a right posterior spike focus. This child is in fact still subject to focal fits.

FIG. 12.—Hypsarrhythmia. Child age 9 years. Shows random high amplitude spikes and slow waves. Note that the gain of the amplifier has been reduced to a quarter of that in most of the other tracings.

FIG. 13.—Television epilepsy. This is taken from the same child as Fig. 3, but shows her resting record, in which a generalized spike discharge is seen. It is evident that abnormalities occur apart from those demonstrated by photic stimulation, but so far the child has only had fits whilst watching T.V.

FIG. 14.—Television epilepsy. Again this is taken from the same child as Fig. 3, but shows her record taken whilst overbreathing. The generalized spike discharge is even more in evidence.

use if the required information has been already obtained by other methods.

It is of interest that Hutchinson, Stone, and Davidson (1958) and also Chao (1962) have reported that some epileptic children will deliberately provoke fits in themselves by looking at the sun and moving their outstretched fingers quickly before their eyes. Even the dazzle effect of check fabric has been known to produce a fit, and television has already been mentioned.

Sleep Patterns

The frequency of the rhythmic patterns in the EEG decreases with increasing drowsiness, so that during sleep generalized slow activity appears. It is perhaps relevant also that brain abnormalities are often associated with slow activity, and epilepsy itself is often nocturnal, so that sleep records provide a useful means of investigation in epilepsy.

A natural sleep record is shown in Fig. 5 and was obtained fortuitously, but more often it is necessary to resort to artificial sleep, preferably by giving quinalbarbitone (seconal) orally. Penthotal can also be given intravenously but it has the disadvantage that it may make the child afraid of subsequent visits. Chlorpromazine given intramuscularly is perhaps less frightening and is often more successful than barbiturates in revealing abnormalities.

Difficulties of Interpretation

The basic rhythmic activity in adults remains remarkably constant for the individual, but in children the basic activity is slower and subject to variations of frequency from day to day, or even from hour to hour. Asymmetry may be present in one recording, but not in a subsequent one, and temporary changes of phase can also occur.

It is, therefore, not easy to be certain if a record is abnormal, but the electrical changes in the recording of epileptic children now to be described are unequivocal and persistent, being readily demonstrable on subsequent occasions.

Epileptic Patterns

For practical purposes the EEG shows only two types of epilepsy, the one characterized by generalized electrical disturbance, the other by focal electrical abnormality, it being possible to demonstrate both these kinds of abnormal activity even in the interictal tracing.

Generalized or Primary Subcortical Epilepsy

In this no pathological changes can be discovered in the brain, and clinically the attacks can be either minor or major, both occurring without warning: genetic factors are important.

The electrical changes arise in subcortical

structures and are transmitted bilaterally and synchronously to the cerebral hemispheres, appearing as generalized wave and spike bursts in the tracing (Fig. 6). Some loss of awareness occurs during this discharge, but the child continues to breathe and his colour remains pink even if the discharge persists for 30 seconds and it sometimes does. Akinetic epilepsy and also myoclonic petit mal show similar electrical changes, though in the latter multiple spikes are reported by Gastaut (1954) as being more characteristic.

Though these children often respond well to medication, it is surprising how many show abnormal electroencephalograms even after control has apparently been established for many years.

Lees and Liversedge (1962) in a review of 132 cases of petit mal epilepsy attending a neurological department over a period of ten years found that only five were free from fits and consequently gave a guarded prognosis for this type of epilepsy.

It is possible that in some cases there may be a hidden focal abnormality which is initiating the generalized electrical abnormality, so called 'secondary activation'.

Focal Epilepsy

In these cases there is a focal pathological condition of the cerebral cortex, such as mesial temporal lobe sclerosis (Falconer and Serafini, 1963), degenerative glial changes, scarring from previous trauma, vascular abnormalities or neoplastic conditions.

Clinically the attacks are heralded by an aura and take the form of major attacks, Jacksonian epilepsy or psychomotor phenomena. Genetic factors are minimal.

The EEG may show focal slow waves or more commonly in children a persistently discharging spike focus, as illustrated in Fig. 7. Accurate localization is usually possible by observing phase differences.

Sometimes these foci migrate or may even disappear, as reported by Gibbs, Gillen and Gibbs (1954). Fig. 8 shows the same child as the previous illustration but taken five years later, when the focus has probably healed.

A natural sleep record, or even a drug-induced sleep record, may sometimes be required before a focus can be revealed, as shown in Fig. 9. If barbiturates are given, generalized fast activity (18-24 c/s) is induced and this too may have localizing value according to Kennedy and Hill (1958), as abnormal cortex may not show this induced response.

During natural sleep, bursts of bilateral fast activity (12-16 c/s) occur in normal children and are known as 'sleep spindles'. In abnormal

cortex these may be diminished in amplitude, or even abolished, and, therefore, also have localizing value, as shown in Fig. 10, where a spike focus and also diminished sleep spindle activity are shown occurring in the same area of cortex.

As already stated, febrile convulsions in children are usually benign but occasionally a spike focus appears in the EEG betokening a more serious prognosis, an example of this being shown in Fig. 11, this child still being subject to epileptic fits several years after the original onset of febrile convulsions.

Hypsarrhythmia

High voltage irregular and almost continuous random spikes and slow waves are found in the clinical condition characterized by 'salaam spasms' to which reference has already been made. The clinical and electrical findings have been described by Gibbs, Fleming and Gibbs (1954).

Such findings indicate gross brain dysfunction but do not constitute a specific pathological entity. Bower and Jeavons (1959) found evidence of prenatal or perinatal brain damage in some of their cases, but reported that most authorities were agreed that in half the cases no ætiological factors could be found.

The electrical findings probably indicate abnormal discharges both from cortical and subcortical sources. An example is shown in Fig. 12.

Television Epilepsy

As mentioned already, some children have fits when watching television under certain conditions. An example of this type of case is given in Fig. 3 where stroboscopic stimulation gives rise to a photo convulsive response.

Whilst this may be the only abnormality in the record of such children, some may show other evidence of epilepsy, usually of subcortical type, apart from photic stimulation. This was the case in this same child whose resting record is shown in Fig. 13, which shows sharp wave bursts, which are augmented during overbreathing, as in Fig. 14.

Alternatively, children with petit mal seizures unassociated with television viewing may show a photo convulsive response as the only abnormality in the tracing.

We are grateful to the two recordists, Mrs. Susan Williams and Miss Jean Mills, for preparing the records and to Mr. L. Hine for the photography.

REFERENCES

- BAIRD, H. W., and GARFUNKEL, J. M. (1956): E.E.G. Changes in Children with Artificially Induced Hyperthermia, *J. Pediat.*, **48**, 28.
- BOWER, B. D., and JEAUVONS, P. M. (1959): Infantile Spasms and Hypsarrhythmia, *Lancet*, **i**, 605.
- CHAO, DORA (1962): Photogenic and Self-induced Epilepsy, *J. Pediat.*, **61**, 733.
- FALCONER, M. A., and SERAFETINIDES, E. A. (1963): A Follow-up Study of Surgery in Temporal Lobe Epilepsy, *J. Neurol. Neurosurg. Psychiat.*, **26**, 154.
- GASTAUT, H. (1954): 'The Epilepsies. Electro-Clinical Correlations'. Springfield, Illinois: Charles C Thomas.
- GIBBS, F. A., FLEMING, M. M., and GIBBS, E. L. (1954): Diagnosis and Prognosis of Hypsarrhythmia.—Infantile Spasms. *Pediatrics*, **13**, 66.
- , GILLEN, H. W., and GIBBS, E. L. (1954): Disappearance and Migration of Epileptic Foci in Children, *Amer. J. Dis. Child.*, **88**, 596.
- HILL, J. D. N. (1963): The E.E.G. in Psychiatry. In 'Electroencephalography', p. 374. London: Macdonald.
- HUTCHINSON, J. H., STONE, H. S., and DAVIDSON, J. R. (1958): Photogenic Epilepsy induced by the Patient, *Lancet*, **i**, 243.
- KENNEDY, W. A., and HILL, J. D. N. (1958): The Surgical Prognostic Significance of the Electroencephalographic Prediction of Ammon's Horn Sclerosis in Epileptics, *J. Neurol. Neurosurg. Psychiat.*, **21**, 24.
- LEES, F., and LIVERSEDGE, L. A. (1962): The Prognosis of 'Petit Mal' and Minor Epilepsy, *Lancet*, **ii**, 797.
- NYMAN, G. E. (1954): E.E.G. in Rheumatic Fever, *Acta. Med. Scand.*, **149**, 127.
- PANTELAKIS, S. N., BOWER, B. D., and JONES, H. D. (1962): Convulsions and Television Viewing, *Brit. med. J.*, **ii**, 633.