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Brain perfusion SPECT in children with frequent fits

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We studied 14 children with frequent fits using ^{99m}Tc-HM-PAO single photon emission computed tomography (SPECT). There were 11 patients with partial secondary generalized epilepsy (PSGE) and 3 with Lennox–Gastaut syndrome (LGS). The typical regional cerebral blood flow (rCBF) finding in PSGE was a single area of abnormally low perfused cortex, and that in LGS, multiple hypoperfused areas. Clinically, the LGS patients were more severely affected. SPECT was more sensitive in detecting abnormalities than EEG, CT or MRI. Extensive impairment of rCBF may thus indicate unfavourable development of intellectual performance and poor seizure control.

Key words: Single photon emission computed tomography (SPECT); Child; Epilepsy

INTRODUCTION

The epileptic syndromes of childhood [1] are grouped into primary (relatively benign and partially inherited) and secondary (often therapy resistant and associated with brain lesions, e.g. Lennox–Gastaut syndrome) ones [2]. As there is no reliable prognostic indicator at the time of diagnosis, new diagnostic methods are needed.

The assessment of regional cerebral blood flow (rCBF) by single photon emission computed tomography (SPECT) has become widely performed since the introduction of the new lipophilic rCBF tracers [3]. With these tracers, abnormalities in cortical and, to some extent, basal structures can be seen. Functional and lesion-related alterations in rCBF are known, and rCBF SPECT may be suitable for confirmation of electroencephalographic seizure localization [4] and for measurement of the activity of an epileptic focus [5]. In epileptic children, rCBF abnormalities may be correlated with the clinical status, e.g. extensive impairment of rCBF may be associated with a high seizure frequency and poor intellectual performance [6,7].

To gather experience of the value of rCBF SPECT in the assessment of children with frequent fits we correlated ^{99m}Tc-hexamethylpropyleneamine oxime (HM-PAO) SPECT findings with clinical and EEG data.

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MATERIAL AND METHODS

Patients

During a 2 year period (April 1987–March 1989) SPECT scans were obtained for 14 children with more than 14 registered fits 2 weeks prior to SPECT scanning.

Classification of epilepsy

The diagnosis of epilepsy was based on the clinical history, physical and neurological examinations, EEG follow-up and CT and/or MRI of the brain. The patients could be classified into two groups [1]: partial secondary generalized epilepsy (PSGE) (11 patients and scans) and Lennox–Gastaut syndrome (LGS) (3 patients and 5 scans). There were 5 boys and 9 girls, of 2–15 years of age.

Assessment of the rCBF results

The perfusion tomograms were scored visually and blindly by two viewers.

Technology

SPECT imaging was performed with a General Electric 400T large field-of-view rotating γ-camera equipped with a low-energy parallel hole collimator. After

intravenous injection of 6.0–14.5 mCi ^{99m}Tc-HM-PAO, 64 frames, at a frame rate of 1 per 30 s, were collected. A set of transverse and coronal tomographic slices were produced with the Gamma-11 software's filtered back-projection algorithm using the modified Shepp–Logan filter. Siemens Elema EEG recorders were used for EEG. The typical EEG finding for each case was extracted from EEG recordings within a year preceding SPECT. CT was performed with a General Electric 8080 or a Siemens Somatom 2 scanner. MRI was performed with a very-low magnetic field (0.02 T) Acutscan scanner.

Statistics

Spearman's rank order correlation coefficient was calculated between each SPECT and clinical variable, and the significance was examined using the chi-square test.

RESULTS

The typical rCBF finding in PSGE was one or two areas of hypoperfused cortex (Figs 1 and 2) and that in LGS was multiple (mean 3) cortical hypoperfusion areas (Fig 3, Table I). Also, clinically, the LGS group was more severely affected (Table I).

EEG and SPECT foci coincided rather well in PSGE. The hypoperfusion and EEG foci were found in the same hemispheric lobe in 6/11 PSGE patients, including two with bilateral rCBF abnormalities. The SPECT and EEG abnormalities were preferentially located in the left temporal area ($r=0.79$, $P<0.001$). The foci were located in different hemispheric lobes in 3/11 cases. In one patient there was an EEG abnormality without hypoperfusion, and in another patient both SPECT and EEG were normal. The EEG foci were correlated with contralateral cerebellar hypoperfusion ($r=0.50$, $P<0.05$), which may demonstrate crossed cerebellar diaschisis. In LGS, multiple foci of hypoperfusion were seen on SPECT, and these patients exhibited a generalized disturbance on EEG.

Only 1/14 patients had a completely normal SPECT scan, whereas in 8/14 CT or MRI was normal. In the patient with the normal SPECT scan, CT and MRI were also normal. The correlation between CT or MRI

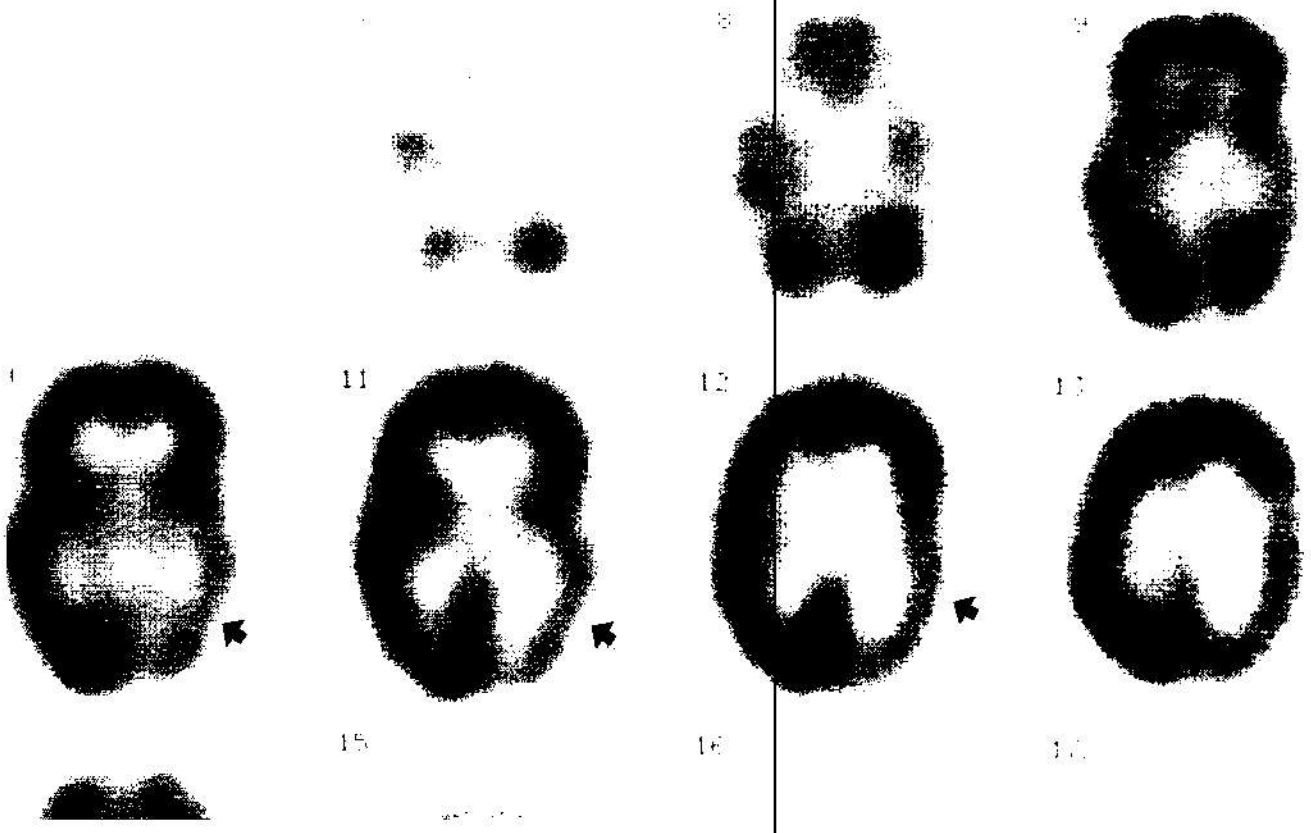

Fig 1. A 9-year-old boy with considerable left temporal, occipital and parietal hypoperfusion.

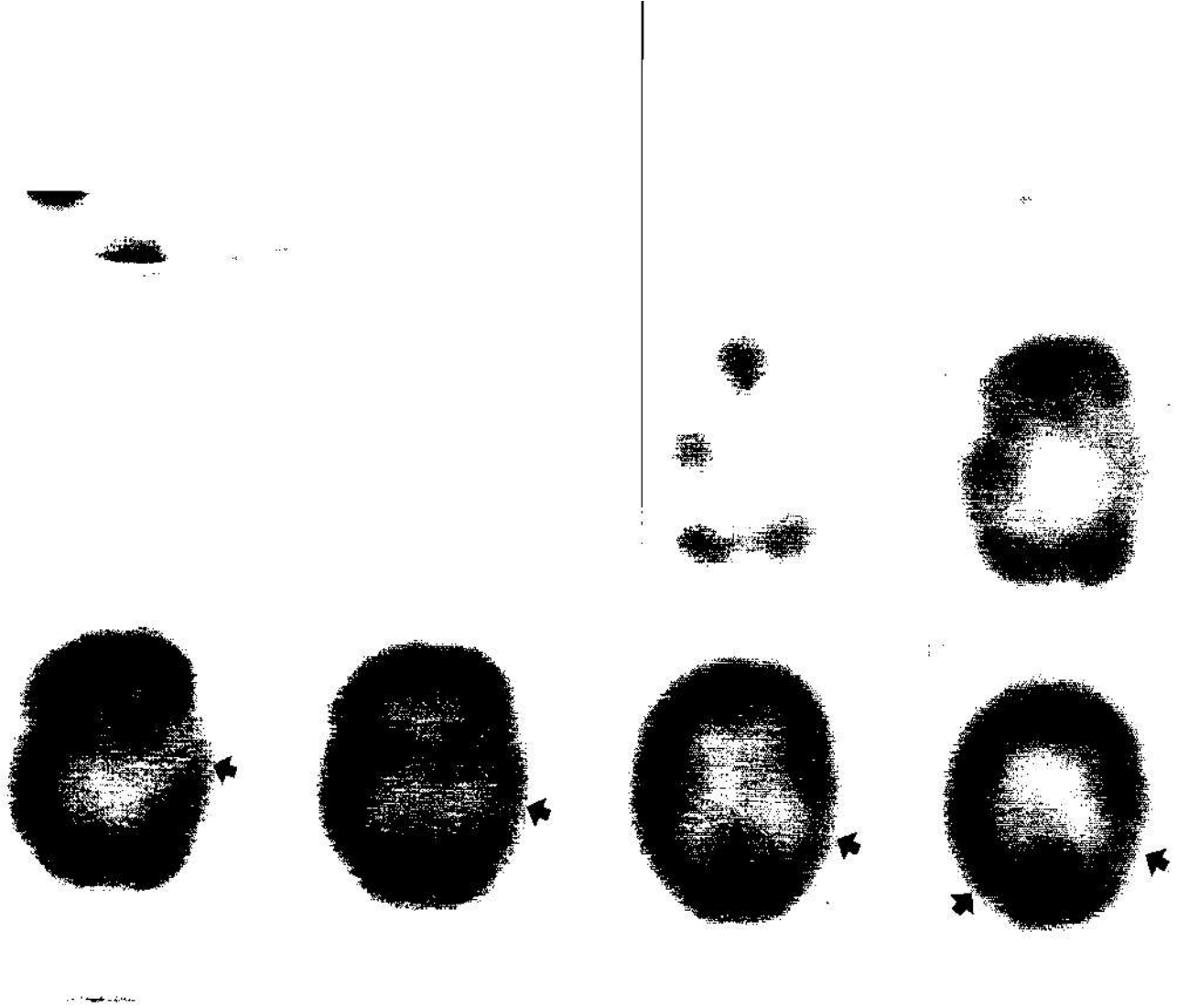

Fig 2. A 5-year-old girl with left temporal, parietal and right parietooccipital hypoperfusion.

abnormality and SPECT abnormality was significant ($r = 0.59$, $P < 0.05$).

DISCUSSION

We found a large number of areas of abnormal perfusion in children with frequent fits. Hypoperfusion, rather than hyperperfusion, was the only kind of pathology found in our patients, studied interictally. This may be due to the rapid progress (about 20 min postictally) from hyper- to hypoperfusion in temporal epilepsy [4]. However, a longer transition period from hyper- to hypoperfusion is also possible [5], and during this transition rCBF may seem normal, thus leading to false-negative results.

The location of hypoperfusion was typically temporoparietal in our PSGE patients. The crossed cerebellar diaschisis-like phenomenon, which is known to occur in contralateral supratentorial abnormalities, was also seen in these patients [7]. Frontal hypoperfusion (Table I) was uncommon because most children had temporal epilepsy. SPECT detected abnormalities more sensitively than CT or MRI [8].

In LGS patients, the multiple perfusion defects were located frontally, temporally and parietally, similar to that demonstrated by positron emission tomography (PET) [10–12]. PET has also been used in proposals of subdivision [11] and pathogenetic mechanisms [12] of LGS. The multifocal nature of the disorder is also seen in depth EEG studies [13]. In these patients, SPECT may be the only routine clinical method capable of revealing the multiple foci.

SPECT and EEG agree reasonably well. Pathology was found with both methods most often in the left temporal area. The discordance of the lateralization of SPECT and EEG findings may be due to false lateralization of the interictal surface EEG findings, or the presence of a metabolically abnormal but non-epileptogenic area in the brain.

Our material is too small to draw prognostic conclusions. However, there was a more similar trend than in previous studies [6,7], with extensive impairment of rCBF pointing towards a poorer prognosis of intellectual performance and seizure control.

Table 1

Clinical, EEG and SPECT data of 14 children with frequent fits

Children with partial secondary generalized epilepsy

Case	Age	Disease duration	No. AEDs[a]	Status abnormality	Development abnormality	CT or MRI	EEG foci									SPECT finding									
							LF	RF	LT	RT	LP	RP	LO	RO	BG	LF	RF	LT	RT	LP	RP	LO	RO	RC	LC
1	2	2	1	Severe	Severe	Abnorm	–	–	–	+	–	–	–	–	M	N	N	N	S	N	M	N	N	N	M
2	4	0	1	Slight	Norm	Norm	–	–	–	–	+	–	–	–	S	N	N	N	M	N	M	N	N	M	N
3	4	3	2	Slight	Slight	Abnorm	–	–	–	+	–	–	–	–	M	N	N	N	N	M	N	M	N	N	N
4	4	2	2	Severe	Severe	Norm	–	–	+	+	–	–	–	–	S	M	N	S	N	N	N	N	N	N	N
5	5	4	1	Severe	Severe	Abnorm	+	–	+	–	+	–	–	–	N	M	N	S	N	S	N	N	N	N	N
6	8	2	2	Slight	Norm	Norm	–	–	+	+	–	–	–	–	M	N	N	S	S	N	N	N	N	S	S
7	9	4	2	Slight	Slight	Norm	–	–	–	+	–	+	–	–	M	N	N	M	N	M	N	N	N	M	N
8	9	8	2	Severe	Severe	Abnorm	–	–	–	–	–	–	–	–	N	N	N	N	N	N	N	N	N	N	N
9	13	13	3	Norm	Slight	Abnorm	+	–	+	–	–	–	–	–	N	N	N	M	N	N	N	N	N	N	N
10	14	11	2	Slight	Slight	Norm	–	+	–	+	–	–	–	–	M	N	N	N	M	N	M	N	N	N	N
11	15	7	2	Slight	Slight	Norm	–	–	–	+	–	–	–	–	N	N	M	N	S	N	M	N	N	N	N

Children with Lennox–Gastaut syndrome

Case	Age	Disease duration	No. AEDs[a]	Status	Mental status	CT or MRI	EEG foci									SPECT finding									
							LF	RF	LT	RT	LP	RP	LO	RO	BG	LF	RF	LT	RT	LP	RP	LO	RO	RC	LC
1	10	5	4	Severe	Severe	Norm	–	–	–	–	–	–	–	–	S	N	N	M	N	N	M	M	N	N	N
2	10	3	5	Severe	Severe	Abnorm	–	–	–	–	–	–	–	–	M	M	M	M	M	N	N	N	N	N	N
2	12	5	5	Severe	Severe	Abnorm	–	–	–	–	–	–	–	–	S	M	N	M	N	M	N	N	N	N	N
3	11	11	5	Severe	Severe	Norm	–	–	–	–	–	–	–	–	M	N	M	N	M	N	M	N	N	N	M
3	12	12	4	Severe	Severe	Norm	–	–	–	–	–	–	–	–	M	N	S	N	M	N	M	N	N	N	N

L, left; R, right; F, frontal; T, temporal; P, parietal; O, occipital; C, cerebellar; BG, back ground; N, normal; M, moderate disturbance/hypoperfusion; S, severe disturbance/hypoperfusion.
[a]Number of different anti-epileptic drugs used during the year before SPECT.

Fig 3. A 10-year-old girl with LGS. There is bilateral temporal and parietal hypoperfusion, as well as hypoperfusion in the frontal lobes.

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