

SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY OF BRAIN PERFUSION: ANALYSIS OF 60 PAEDIATRIC CASES

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Single-photon emission computed tomography (SPECT) has been increasingly applied to the study of brain perfusion in a number of neurological diseases, including stroke (Ell *et al.* 1985, Podreka *et al.* 1987), epilepsy (Bonte *et al.* 1983, Lee *et al.* 1986, Gjerstad *et al.* 1987, Stefan *et al.* 1987, Podreka *et al.* 1987), encephalitis (Launes *et al.* 1988) and dementia (Brun and Englund 1986, Gemmel *et al.* 1987). Experience so far has largely been limited to adult patients and there have been few reports on children (*e.g.* Gainey and Capitanio 1988).

To assess the value of brain perfusion SPECT in children, we analysed the results for all paediatric patients studied at the Helsinki University Central Hospital to date. We also related the SPECT findings to relevant laboratory and clinical data to assess the clinical value of this method for children.

Patients and method

By the end of May 1988, 69 brain perfusion SPECTs had been performed on 60 patients referred to the Children's Hospital, Helsinki University Central Hospital. 22 were male and 38 were female, and their ages ranged from newborn to 27 years (mean 10.3, SD 5 years). A 27-year-old male with juvenile neuronal ceroid lipofuscinosis and a 19-year-old female with subacute sclerosing

panencephalitis had been followed since their childhood. All the other patients were less than 18 years of age.

Epilepsy was the most common clinical diagnosis, followed by cerebrovascular diseases, encephalitis and degenerative brain diseases (Table I). An oligodendroglioma was revealed in one case with focal epilepsy. Cerebral haemangioendothelial sarcoma had been diagnosed four years earlier in a case with cerebral infarction. Two patients had movement disorders: torsion dystonia and choreoathetoid dyskinesia.

The impact of brain perfusion SPECT on the final diagnosis was defined by one of us (H.P.) as minimal, moderate, great, decisive, or misleading.

SPECT imaging was done with a General Electric 400T large field-of-view rotating gamma camera equipped with a low-energy parallel hole collimator. After intravenous injection of 10.0 to 14.5 mCi ^{99m}Tc HM-PAO, 64 frames, with a frame rate of one per 30 seconds, were collected. For analysis of side-to-side differences, regions of interest were drawn on 42 predefined sites of six tomographic slices in each study. Scaling was done by dividing mean counts/pixel per min (CPM) of each region of interest by the mean CPM rate of all other regions of interest. SPECT scans were read blindly by one of the authors (J.L.).

TABLE I
Clinical diagnoses for 60 patients with brain perfusion SPECT studies

Diagnoses	N	%
Epilepsy	22	37
Focal	16	
Lennox-Gastaut syndrome	6	
Cerebrovascular diseases	13	22
Cerebral infarction	7	
Migraine <i>accompagné</i>	5	
Intracerebral haemorrhage	1	
Encephalitis	8	13
Subacute sclerosing panencephalitis	1	
Reovirus encephalitis	1	
Nondefined encephalitis	6	
Degenerative brain diseases	10	17
Juvenile neuronal ceroid		
lipofuscinosis	6	
Metachromatic leucodystrophy	1	
Nondefined progressive encephalopathy	3	
Other disorders	7	12
Nondefined encephalopathy	3	
Movement disorder	2	
Pons tumour	1	
Psychosis	1	

EEGs were registered from all 60 patients, using Elema equipment. Non-contrast or contrast CT scans were also performed on all 60 patients, using General Electric 8080 or Siemens Somatom 2 scanners. Magnetic resonance images (MRIs) were available for 41 patients. They were obtained with the Acutscan device, manufactured by Instrumentarium Corp., Helsinki, operating with a magnetic field of 0.02T. T₁-weighted inversion recovery and T₂-weighted spin-echo images were used. The slice thickness was 15mm. The images were displayed on a matrix of 128 × 256 pixels.

The study was approved by the Ethics Committee of our Hospital and informed consent was obtained in each case.

Results

Brain SPECT showed abnormal perfusion in 41 (59 per cent) of the 69 scans performed. SPECT findings were normal in 16 scans (23 per cent) and equivocal in the remaining 12 (17 per cent). SPECT was abnormal more frequently in degenerative brain diseases than in other pathological conditions, including epilepsy, encephalitis and cerebrovascular diseases (Table II). Examples of brain perfusion SPECT scans are shown in Figures 1 to 6: these

represent the following main diagnostic categories: local hypoperfusion in focal epilepsy (Fig. 1), bilateral hypoperfusion in Lennox-Gastaut syndrome (Fig. 2), hypoperfusion corresponding to infarct of the middle cerebral artery (Fig. 3), two hypoperfusion areas in encephalitis (Fig. 4), local hypoperfusion in progressive encephalopathy of unknown origin (Fig. 5), and large hemispherical hypoperfusion in juvenile neuronal ceroid lipofuscinosis (Fig. 6).

Comparison of the SPECT findings with those obtained by EEG, CT or MRI showed that SPECT was the most sensitive in revealing brain abnormalities. The SPECT was abnormal in 59 per cent, while the corresponding percentages for EEG, CT and MRI were 53, 24 and 23, respectively.

Brain perfusion SPECT was diagnostically decisive in two cases (epilepsy, encephalitis), but was misleading in two other cases (epilepsy, encephalitis). In 15 cases the SPECT findings were of considerable value for the ultimate diagnosis (Table III). Of the 69 SPECT studies performed, 44 (64 per cent) had influence on the final diagnosis: 28 were of confirmatory value in suspected cases and 12 did not support the suspected diagnosis. The remaining 25 scans (36 per cent) had no impact on the final diagnosis.

Discussion

Brain perfusion SPECT was abnormal most frequently in patients with degenerative brain diseases (82 per cent), followed by epilepsy (63 per cent), encephalitis (62 per cent), cerebrovascular diseases (43 per cent) and other disorders (43 per cent). SPECT was more sensitive than EEG, CT or MRI in showing brain abnormalities (59, 53, 24 and 23 per cent, respectively).

Although highly sensitive, SPECT was not very specific. However, in some instances the information it gave was decisive in the diagnosis. In general, SPECT findings should be related to laboratory and clinical data; and sometimes re-examination with SPECT during the course of the disease will facilitate the diagnosis, as, for instance, in *Herpes simplex* encephalitis (Launes *et al.* 1988). Basically, the present brain SPECT results in children agree with those obtained in adults (Podreka *et al.* 1987),

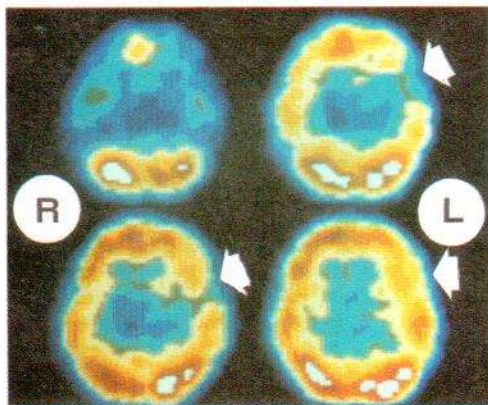


Fig. 1. Four-year-old girl with focal epilepsy and left temporal EEG focus. Inter-ictal SPECT showed hypoperfusion in corresponding area of left temporal lobe.

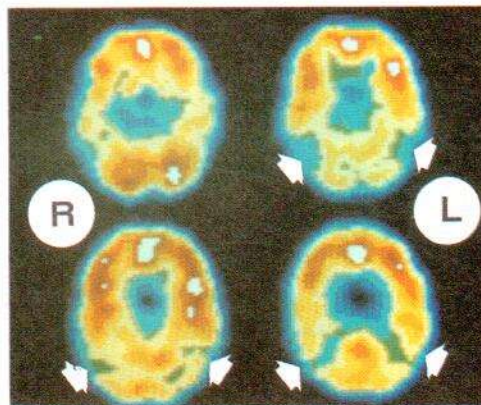


Fig. 2. Nine-year-old girl with Lennox-Gastaut syndrome. SPECT showed marked hypoperfusion bilaterally in temporal and parietal lobes.

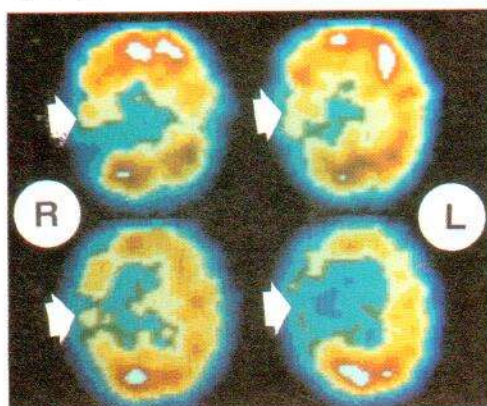


Fig. 3. 14-year-old girl with cerebral infarction. SPECT showed large area of hypoperfusion corresponding to vascular territory of right medial cerebral artery.

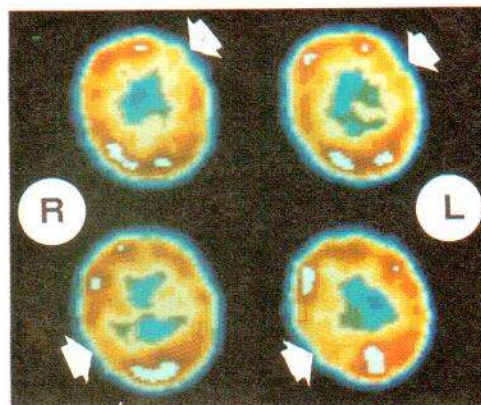


Fig. 4. One-year-old girl with reovirus encephalitis which could not be distinguished from Herpes simplex encephalitis by clinical, EEG and CT findings. SPECT showed modest hypoperfusion in right frontoparietal and left frontotemporal areas, which both became normal within three months. Isolation of reovirus from sample of faeces taken six days after onset verified virological diagnosis.

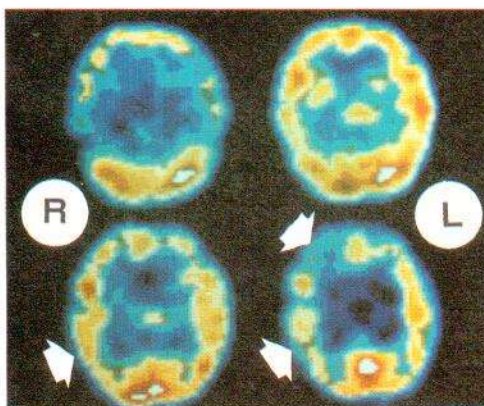


Fig. 5. 13-year-old mentally retarded girl with nondefined progressive encephalopathy. SPECT showed hypoperfusion in right hemisphere.

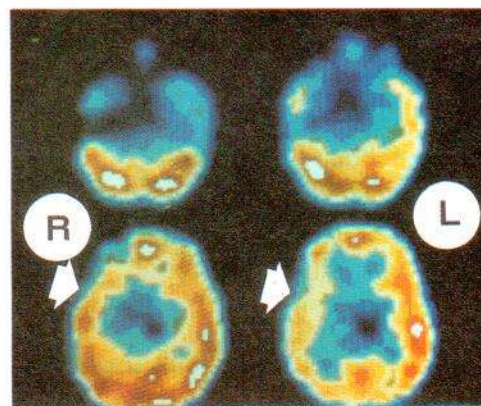


Fig. 6. 10-year-old boy with juvenile neuronal ceroid lipofuscinosis. SPECT showed a large area of hypoperfusion in right frontal and temporal lobes.

TABLE II
Brain perfusion SPECT findings according to main diagnoses

SPECT finding	DIAGNOSES									
	Degenerative brain diseases		Epilepsy		Encephalitis		Cerebro-vascular diseases		Other	
	N	%	N	%	N	%	N	%	N	%
Abnormal	9	82	15	63	8	62	6	43	3	43
Normal	0		4	17	3	23	6	43	1	14
Uncertain	2	18	5	21	2	15	2	14	3	43

*N = number of SPECT studies.

TABLE III
Estimated value of brain perfusion SPECT for diagnosis

Estimated value	Epilepsy (N=24*)		Cerebro-vascular diseases (N=14)		Encephalitis (N=13)		Degenerative brain diseases (N=11)		Other (N=7)	
	N	%	N	%	N	%	N	%	N	%
Minimal	8	33	5	36	4	31	3	27	3	43
Moderate	8	33	5	36	2	15	8	73	4	57
Great	6	25	4	28	5	38	0		0	
Decisive	1	4	0		1	8	0		0	
Misleading	1	4	0		1	8	0		0	

*N = number of SPECT studies.

which showed the superior value of SPECT over CT in the diagnosis of stroke and epilepsy.

Although ^{99m}Tc HM-PAO SPECT is a perfusion imaging method, it is evident that it is applicable to the study of degenerative brain diseases, epilepsy and encephalitis, which are not primarily vascular disorders. We therefore recommend brain perfusion SPECT for children when these diseases or stroke are suspected.

The findings obtained by brain SPECT should be compared with those obtained by other imaging methods, especially by positron emission tomography (PET). PET has better resolution and provides quantitative data, but is costly to acquire and operate. Therefore the relatively inexpensive SPECT techniques have to be used if tomographic demonstration of perfusion abnormalities—hypoperfusion or hyperperfusion—is to play a part in the care of children with degenerative diseases,

epilepsy, encephalitis or cerebrovascular diseases. The total radiation dose from brain SPECT is smaller than from CT of the head, and gonadal doses are about one-tenth of those from X-ray examination of the pelvic region. As the radiation dose from SPECT is comparatively small, there are no absolute contraindications to its application; the necessary instrumentation is available in most large and medium-sized hospitals, so the use of SPECT will increase. It is likely that there will be new indications for brain perfusion SPECT studies in children, but it is already an important supplementary method in the diagnosis of cerebral diseases in children.

Accepted for publication 28th February 1989.

Acknowledgements

We thank Dr. Kristian Liewendahl (Chief, Division of Nuclear Medicine) for valuable assistance in the preparation of this manuscript. This study was financially supported by the Finnish Cultural Funds and the Instrumentarium Science Foundation.

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SUMMARY

Sixty-nine brain perfusion single-photon emission computed tomography (SPECT) scans were performed on 60 paediatric patients with various neurological diagnoses. SPECT was abnormal more frequently in degenerative brain diseases (82 per cent), than in epilepsy (63 per cent), encephalitis (62 per cent), cerebrovascular disease (43 per cent), or other brain disorders (43 per cent). SPECT was more sensitive than EEG, CT and MRI results. SPECT was of considerable value for diagnosis in many cases. It was a decisive aid in two cases, but misleading in another two, so SPECT must be related to findings obtained by clinical and other laboratory methods.

RÉSUMÉ

Tomodensitométrie après perfusion cérébrale à émission de photons isolés: analyse de 60 cas pédiatriques

Soixante-neuf scanners à émission de photons isolés, par perfusion cérébrale, (SPECT), ont été pratiqués chez 60 cas pédiatriques après des diagnostics neurologiques variés. Le SPECT était plus fréquemment anormal dans les affections dégénératives du cerveau (82 pour cent) que dans l'épilepsie (63 pour cent), l'encéphalite (62 pour cent), les affections cérébro-vasculaires (43 pour cent) ou pour les autres troubles cérébraux (43 pour cent). Le SPECT s'est montré plus sensible que l'EEG, le simple scanner ou l'IRM et le SPECT est de valeur diagnostique considérable dans de nombreux cas. Il a constitué un point décisif de diagnostic dans deux cas et a conduit à erreur dans deux autres cas; il doit donc être relié données de la clinique et des autres méthodes de laboratoire.

ZUSAMMENFASSUNG

Bestimmung der Hirnperfusion mit Einzel-Photon-Computertomographie: Analyse von 60 pädiatrischen Fällen

Bei 60 pädiatrischen Patienten mit verschiedenen neurologischen Diagnosen wurden 69 Hirnperfusionsuntersuchungen mit Einzel-Photon-Computertomographie (SPECT) durchgeführt. SPECT war bei degenerativen Hirnerkrankungen (82 Prozent) häufiger abnorm, als bei Epilepsie (63 Prozent), Enzephalitis (62 Prozent), cerebrovaskulärer Erkrankung (43 Prozent) oder anderen Hirnerkrankungen (43 Prozent). SPECT war genauer, als EEG, CT und MRI Befunde. SPECT war in vielen Fällen von beträchtlichem diagnostischem Wert. Es war in zwei Fällen eine Entscheidungshilfe, in zwei anderen Fällen jedoch irreführend, daher sollte SPECT mit klinischen und andere Laborbefunde in Beziehung gesetzt werden.

RESUMEN

Tomografía computarizada por emisión de un fotón en perfusión cerebral: análisis en 60 casos pediátricos

Se practicaron 69 tomografías computarizadas por emisión de un fotón (TCEF) en perfusión cerebral en 60 pacientes con diversas enfermedades neurológicas. La TCEF era anormal con mayor frecuencia en enfermedades cerebrales degenerativas (82 por ciento), que en la epilepsia (63 por ciento), encefalitis (62 por ciento), enfermedad cerebrovascular (43 por ciento) y otras enfermedades cerebrales (43 por ciento). La TCEF era más sensible que el EEG, TAC y IRM. Fue de gran ayuda par el diagnóstico en muchos casos. Su ayuda fue decisiva en dos casos, pero falló en otros dos, por lo que la TCEF debe considerarse siempre en relación con hallazgos obtenidos por la clínica y otros métodos de laboratorio.

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