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The relevance of interictal rCBF brain SPECT in temporal lobe epilepsy: Diagnostical value and effects of spatial resolution

Christian MENZEL,* Andreas HUFNAGEL,** Frank GRÜNWALD,* Laszlo PAVICS,***,† Karl REICHMANN,* Christian E. ELGER** and Hans J. BIERSACK*

**Department of Nuclear Medicine, University of Bonn, Germany*
***Department of Epileptology, University of Bonn, Germany*
****Department of Nuclear Medicine, University of Szeget, Hungary*

Interictal rCBF-SPECT is frequently being used as an adjunctive method for localization of an epileptogenic area during presurgical evaluation of patients suffering from medically refractory temporal lobe epilepsy. This study retrospectively evaluates interictal rCBF-SPECT using Tc-99m-HMPAO in comparison to the results of MRI. The final results of surface EEG and ECoG and the post-surgical clinical results as to seizure frequency were used as a 'gold-standard' for the evaluation of both imaging procedures.

As spatial resolution is discussed to be the major reason for higher sensitivity of F-18-DG-PET compared to rCBF-SPECT, special attention has been paid to the spatial resolution of the different SPECT systems being used in this study. In 55 patients the complete data set could be obtained retrospectively, 36 of them being evaluated using SPECT systems with relatively low spatial resolution (Picker Dyna 2000, Elscint Helix) and 19 pt. being evaluated using moderate- to high-resolution SPECT systems (ADAC Genesys, DSI Ceraspect). Overall sensitivity of the interictal rCBF-SPECT was 75%, with 69% for low-resolution systems and 84% for high-resolution systems. Approximately at the same time when our institution installed the ADAC Genesys, the MRI equipment was changed from the 1.5 T Philips Gyroscan S15 to the 1.5 T Philips Gyroscan ACS II, the latter allowing superior imaging opportunities. Overall sensitivity of MRI was 60%, with 56%, for the Gyroscan S15 and 68% for the Gyroscan ACS II. The overall positive predictive value (PPV) was 87% for the interictal rCBF-SPECT and 87% for the MRI. Due to the lack of true negative studies in this population specificity was not calculated. False lateralization using rCBF-SPECT occurred in 5 pt. (9%), however in 3 pt. the area of hypoperfusion correlated with a detectable MRI pathology, yet EEG/ECoG revealed the epileptogenic focus to be elsewhere. In conclusion, the interictal rCBF-SPECT revealed reasonable sensitivity and PPV in pt. suffering from focal temporal lobe epilepsy and modern SPECT systems showed significantly improved results. Since there is a variety of possible reasons for regional cortical hypoperfusion, the interictal SPECT could add significant information prior to the application of ECoG. This specially appeared to be useful in patients with a normal MRI scan. Furthermore, in patients presenting with a clear pathology on MRI and a corresponding EEG focus, ECoG could be avoided if the interictal rCBF-SPECT additionally showed localized and singular involvement of the affected temporal lobe. ECoG was mainly applied in those patients with relatively wide-spread hypoperfusion additionally involving frontal or parietal cortical areas.

Key words: rCBF-brain SPECT, epilepsy, Tc-99m-HMPAO

INTRODUCTION

DURING PRESURGICAL EVALUATION of patients with medically intractable epilepsy, magnetic resonance imaging (MRI) and interictal 'single-photon' emission computed tomography (SPECT) of regional cerebral blood flow (rCBF) are routinely performed in our institution.

Tc-99m-hexamethyl-propylene-amine-oxime (HMPAO) was used as a tracer for rCBF. Furthermore, extensive electroencephylography (EEG), including video-monitoring and in many cases electrocorticography (ECoG) are applied.

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For reprint contact: Christian Menzel, M.D., Klinik und Poliklinik für Nuklearmedizin der Universität Bonn, Sigmund-Freud-Str. 25, 53105 Bonn, GERMANY.

†Dr. Pavics is a fellow of the Alexander von Humboldt Foundation.

Table 1 Acquisition parameters of the standard protocol using the Gyroscan ACS II

Seq.	Ang.	Scant.	Matrix	TR [ms]	TE [ms]	NSA	FOV [mm]	THK [mm]
SE-T1	sag.	2.39	154 × 256	500	15	2	250	5.0/1.0
SE-T1	tra.	3.05	205 × 256	550	15	2	230	6.0/0.6
IR-T1	cor.	6.07	205 × 256	2,200	16	1	220	6.0/1.5
SE-prot.	tra.	8.06	205 × 256	2,315	20	1	230	6.0/0.6
SE-T2	tra.	—	205 × 256	2,315	90	1	230	6.0/0.6
TSE-T2	tra.	3.45	246 × 256	2,395	120	4	220	2.0/0.3
TSE-T2	cor.	6.10	248 × 256	3,592	120	4	220	2.0/0.3

Seq.: Sequence; SE: spin echo; IR: inversion recovery; prot.: proton; TSE: turbo spin echo; sag.: sagittal; tra.: transaxial; cor.: coronal; Scant.: scan time; NSA: number of signal averages; FOV: field of view; THK: slice thickness/gap

The association of morphological alterations detected by MRI to a corresponding EEG/ECoG focus is the basis for surgical intervention in many patients. The continuing technical improvements of MRI allow to detect increasingly smaller structural abnormalities.[1,2] Hippocampal sclerosis, for example, today can easily be detected and (semi-)quantitative measurement of hippocampal signal and volume appears to allow detection of temporomesial pathology or hippocampal neuronal loss at an early stage.[3,4] Bitemporal pathologies of the hippocampus seem to be evaluable using this technique as well. Still, MRI is normal in approximately one third of all patients suffering from epilepsy and in approximately twenty-six percent of those who suffer from temporal lobe epilepsy.[5] In addition, the epileptogenicity of a detectable morphological alteration must still be proven.

rCBF-SPECT using tracers like Tc-99m-HMPAO has proven to detect areas of hypoperfusion corresponding to the EEG-focus in most cases[6,7] and a higher sensitivity has been described for this method in focal epilepsy compared to the MRI.[8] The non-specificity of the interictal rCBF-SPECT, the detection of relatively large areas of hypoperfusion in many patients and the—until recently—relatively poor spatial resolution, are well known limitations of this method. In the recent years a number of studies evaluated the sensitivity of either interictal rCBF-SPECT or interictal positron-emission-tomography (PET) using F-18-deoxyglucose (F-18-DG-PET) and those studies, which directly correlated both procedures described a higher sensitivity for PET in interictal evaluation of epilepsy, namely due to its higher spatial resolution.[9] The rCBF and regional cerebral glucose utilization (rCGU) are known to be closely linked in most clinical situations and only for certain postictal periods a disconnection of cerebral blood flow and cerebral metabolism is discussed. However, during the interictal state of epilepsy there is no evidence that both would not closely reflect the same type of information.[10] The rCGU-PET using F-18-DG was found to have higher sensitivity in interictal studies than the rCBF-PET using O-15 labeled water, possibly due to technical factors.[11]

With the development of high-resolution SPECT systems, dedicated for brain SPECT imaging, first reports appeared that showed reasonable compatibility of PET and SPECT.[12] Furthermore, reports focussing on interictal evaluation of epilepsy showed comparable sensitivity between PET and SPECT in this indication[13,14] and ictal rCBF-SPECT has proven to show superior sensitivity in the evaluation of epilepsy, regardless which imaging procedure has been used tor correlation.

This retrospective study was designed to evaluate the influence of spatial resolution on the sensitivity of interictal rCBF-SPECT studies.

METHODS

Patient population

Retrospectively in 55 adult patients suffering from medically refractory temporal lobe epilepsy the complete data set consisting of the results of the interictal rCBF-SPECT, MRI, EEG and ECoG and the post-surgical seizure frequency were available.

Thirty-six patients (m : f = 19 : 17; mean age 33.6 years, range 18 to 52 years) were evaluated using SPECT systems with relatively low-resolution (Picker Dyna, Elscint Helix) and the 1.5 T Philips Gyroscan S15 (Group A). Nineteen patients (m : f = 10 : 9; mean age: 29.3 years; range 18 to 49 years) were evaluated using high-resolution SPECT-systems (ADAC Genesys, DSI Ceraspect) and the 1.5 T Philips Gyroscan ACS II (Group B). Details of the different SPECT systems are given in Table 2..

The mean post-surgical follow-up was 37 months tor group A (range 20 to 45 months) and 16 months tor group B (range 3 to 20 months). No significant differences as to sex and age can be seen. Group B, however, shows a significantly shorter post-surgical follow-up.

MRI studies

Regardless to the MR-tomograph (Philips Gyroscan S15 or ACS II) being used, all patients received sagittal and transaxial T1-weighted spin-echo-(SE)- and T2/proton-weighted-SE-sequences. The application of Gadolinium-DTPA was done only in patients with suspected malignomas, encephalitis and vascular malformations. The Philips Gyroscan ACS II furthermore allowed the routinely performed addition of coronal T1-weighted

Table 2 Acquisition parameters and spatial resolution of the different SPECT systems

System	FWHM	Scant.	NOH	Coll.	Matrix	Proj.	PS	Filter
Picker Dyna	18*	40	two	LEHR	64 × 64	64	6	Metz
Elscint A409	16*	40	one	LEHR	64 × 64	64	6	Hann
ADAC Genesys	10	40	one	LEHR	64 × 64	64	4[1]	Butterworth
DSI Ceraspect[2]	8	30	ring[3]	LEHR	128 × 128	120	1.67	Butterworth

FWHM: full width at half maximum, *estimated under clinical conditions; Scant.: scan time [min]; NOH: number of heads; Coll.: collimator; Proj.: number of projections; PS: pixel size [mm]; [1]: zoom factor 2; [2]: initial acquisition of 64 slices, distance in between equivalent to 1 pixel; [3]: equivalent to three heads.

inversion recovery-(IR)-sequences and especially thin coronal and transaxial T2-weighted turbo-spin-echo-(TSE)-sequences. The angulation of the transaxial sequences followed the long axis of the temporal lobes and coronal sequences were adjusted automatically to a rectangular position in relation to the transaxial slices.

The total scan time was approximately 30 to 40 minutes in all patients. However, mainly due to faster data acquisition, within this time significantly more scans were done using the ACS II. The acquisition parameters for the Philips Gyroscan ACS II are given in Table 1.

SPECT studies

The SPECT studies were done 20 to 60 minutes after the i.v.-injection of 20 mCi (740 MBq) Tc-99m-HMPAO. Injection was performed in a quiet room with the patient's eyes open. The tracer was injected without EEG-control, however, it was assured that the patient had no clinical seizures during the last 6 hours prior to the injection. The acquisition parameters of the different SPECT systems being used are given in Table 2. Full width at half maximum (FWHM) as described in Table 2 is estimated for the different SPECT systems according to technical differences of the cameras leading to a different radius of rotation during acquisition and different filters and filter parameters being used for back-projection.

Routinely colour-coded transaxial (orbitomeatal), sagittal and coronal slices of 4 pixel thickness were reconstructed as well as transaxial slices of one pixel thickness following the long axis of the temporal lobes. Significantly different pixel-sizes within the different SPECT systems therefore lead to a different slice thickness. On basis of the different FWHM of the systems the evaluation of the scan still followed a routine protocol.

The major criterion used for evaluation was an asymmetrically decreased tracer accumulation. A suspected hypoperfusion had to be evident in at least two planes (usually transaxial and coronal) and was judged to be positive if visible on either one slice each if a slice thickness of 4 pixel was used or 3 slices if a slice thickness of 1 pixel was used. The visual evaluation was done by two experienced nuclear physicians, who were unaware of the results of EEG and MRI.

EEG/ECoG

All patients received long-term scalp EEG monitoring. Electrodes were placed according to the international 10/20 system and included sphenoidal electrodes in all patients. ECoG was recorded from chronically implanted subdural electrode strips and longitudinally inserted intrahippocampal depth electrodes and visually analyzed. At least 3 seizures had to he registered in every patient. Criteria by which interictal epileptiform potentials were distinguished from non-epileptiform potentials were similar to those of Gloor,[15] namely: isolated paroxysmal waves with triangular form, lasting less than 80 milliseconds (spikes) or between 80 and 200 milliseconds (sharp-waves), optionally followed by a slow afterpotential (slow-wave) with rapidly inclining and less rapidly declining phase and with an amplitude of at least twice that of the proceeding 5 seconds of background activity. Only the final EEG/ECoG diagnosis was used for correlation with MRI and SPECT findings and no differentiation was made between the degree and value of EEG versus ECoG concerning clinical information in this study.

RESULTS

As a result of the presurgical work-up the 55 patients underwent epilepsy surgery and the post-surgical outcome, measured as a decrease in seizure frequency, was good in 51 patients or 94%. Only 4 patients had less than 75% reduction of seizure frequency after surgery. One of them (# 55) showed left temporal hypoperfusion in the rCBF-SPECT using a low-resolution SPECT system and a corresponding hippocampal lesion in the MRI scan but multiple areas of origin of epileptogenic activity in the EEG. Furthermore, one patient (# 54) showed bi-temporal epileptogenic EEG activity with a strong dominance to the right side and a left temporal MRI/SPECT lesion, using a low-resolution SPECT system again. No ECoG was done in this patient and he showed > 75% reduction in seizure frequency after left temporal surgery which revealed an astrocytoma. Both patients were considered as being operated primarily on basis of MRI and SPECT but rather against the EEG result. The results of the presurgical work-up of the remaining 53 patients as well as the post-surgical seizure frequency are given in Table 3 a–d.

Table 3a Patients with complete presurgical match of MRI, EEG/ECoG and interictal rCBF-SPECT grouped according to the application of low- (group A) and high-resolution SPECT systems (group B)

	No.	Sex	Age	ST	ECoG	MRI diagnosis	Lat.	DSF
Group A	1	m	40	CPS	–	ganglioglioma	L	100%
	2	m	18	CPS	+	small tumor	R	100%
	3	m	28	CPS	+	venous angioma	R	100%
	4	m	30	CPS	+	hippo. atrophy	R	100%
	5	f	28	CPS	–	astrocytoma I	L	100%
	6	m	52	CPS, SG	–	gliosis	R	100%
	7	m	41	CPS	+	hippo. lesion	R	100%
	8	f	41	CPS	+	hippo. atrophy	R	100%
	9	m	25	CPS	+	hippo. lesion	L	100%
	10	f	33	CPS	–	hippo. lesion	R	100%
	11	m	20	CPS	–	hippo. sclerosis	L	100%
	12	f	31	CPS	–	low-grade tumor	R	100%
	13	f	39	CPS	–	hippo. sclerosis	L	100%
	26	m	29	CPS	–	gliosis	L	> 75%
	27	m	49	CPS	+	hippo. atrophy	L	> 75%
	29	f	27	CPS	–	oligodendroglioma	R	< 75%
Group B	14	f	40	CPS	–	hippo. atrophy	R	100%
	15	f	21	CPS	–	hippo. sclerosis	L	100%
	16	m	31	CPS	–	low-grade tumor	L	100%
	17	f	25	CPS	–	low-grade tumor	L	100%
	18	f	49	CPS	–	cavernoma	L	100%
	19	m	27	S/CPS	+	hippo. atrophy	L	100%
	20	f	20	CPS	–	hippo. sclerosis	L	100%
	21	f	18	CPS	+	gliosis	L	100%
	22	m	23	CPS	+	hippo. sclerosis	L	100%
	23	m	28	CPS	–	low-grade tumor	R	100%
	24	m	42	CPS	–	post-trauma lesion	R	100%
	25	m	26	CPS	+	hippo. sclerosis	R	100%
	28	m	36	CPS	–	low-grade tumor	R	> 75%

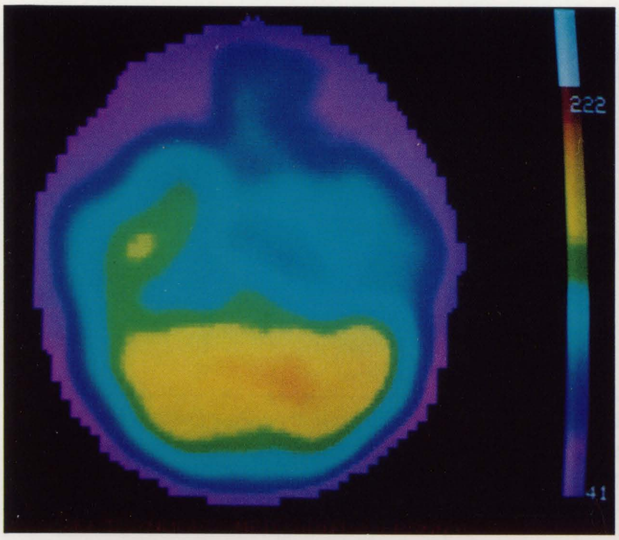
ST: seizure type; SPS: simple partial seizures, CPS: complex partial seizures; SG: secondary generalization: m: male, f: female; Age [years]; hippo.: hippocampus; Lat.: lateralization; R: right side, L: left side; DSF: post-surgical decrease of seizure frequency in comparison to pre-surgical seizure frequency.

Table 3b Match of EEG/ECoG and the interictal rCBF-SPECT, but normal MRI. Patients grouped according to the application of low- (group A) and high-resolution (group B) SPECT systems

	No.	Sex	Age	ST	ECoG	MRI diagnosis	Lat.	DSF
Group A	30	m	38	CPS	+	normal	L	100%
	31	m	34	CPS	+	normal	L	100%
	32	f	18	CPS	+	normal	L	100%
	33	f	37	CPS	+	normal	L	100%
	34	m	41	CPS	+	normal	L	100%
	35	f	41	CPS	+	normal	R	100%
	36	f	18	CPS	+	normal	R	100%
	37	f	25	CPS	+	normal	L	100%
	40	m	34	CPS	+	normal	L	< 75%
Group B	38	m	18	CPS	+	normal	R	100%
	39	f	41	CPS	+	normal	L	> 75%
	41	m	26	CPS	+	normal	L	< 75%

ST: seizure type; SPS: simple partial seizures, CPS: complex partial seizures; m: male, f: female; Age [years]; Lat.: lateralization; R: right side, L: left side; DSF: post-surgical decrease of seizure frequency in comparison to pre-surgical seizure frequency.

The majority of patients (n = 29) showed a complete correspondence of the EEG, MRI and interictal rCBF-SPECT and only 38% of them underwent ECoG prior to surgery (Table 3a). The post-surgical decrease of seizure frequency was good to perfect in all but one of them. This patient developed a recidive of an oligodendroglioma



a

b

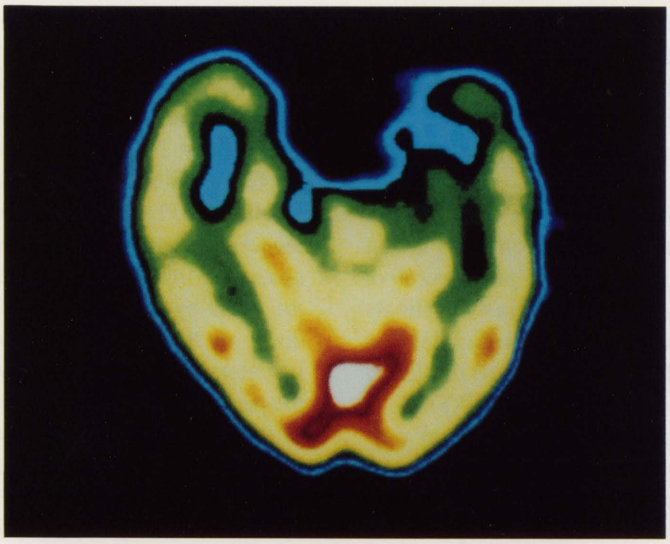


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Fig. 1 Typical results in partial temporal lobe epilepsy in different patients; angulation parallel to the long axis of the temporal lobe: a. Elscint A409, b. ADAC Genesys, c. DSI Ceraspect. Note the different demarcation of anatomical–especially temporomesial–structures.

Table 3c Match of MRI and EEG/ECoG, but normal or inconclusive rCBF-SPECT (group A only)

	No.	Sex	Age	ST	ECoG	MRI diagnosis	Lat.	DSF
Group A	42	m	19	CPS	+	hippo. lesion	R	100%
	43*	f	33	CPS	+	arachnoidal cyst	R	100%
	44*	m	31	CPS	+	hippo. lesion	R	100%
	45	f	29	S/CPS	+	low-grade tumor	R	100%

ST: seizure type; SPS: simple partial seizures, CPS: complex partial seizures; m: male, f: female; Age [years]; Lat.: lateralization; R: right side, L: left side; DSF: post-surgical decrease of seizure frequency in comparison to pre-surgical seizure frequency; * indicates bitemporal epileptiform EEG activity with rCBF-SPECT showing hypoperfusion contralateral to the site of surgery; no patients of group B presented this (3c) presurgical situation.

during follow-up.

In 12 patients the MRI was normal but rCBF-SPECT and the EEG results corresponded well and 10/12 (83%) underwent surgery with good to perfect results. All patients, however, underwent ECoG prior to surgery (Table 3b).

Four patients (Table 3c) underwent surgery because of corresponding EEG/ECoG and MRI and post-surgi-

Table 3d Diagnosis using EEG/ECoG only, as both MRI and rCBF-SPECT were normal or inconclusive. Patients grouped according to the application of low- (group A) and high-resolution (group B) SPECT systems

	No.	Sex	Age	ST	ECoG	MRI diagnosis	Lat.	DSF
Group A	46	f	42	CPS, SG	+	normal	L	100%
	47	f	44	CPS	+	normal	R	100%
	48	f	23	CPS	+	normal	L	100%
	49[1]	m	24	CPS	+	normal	L	100%
	53	f	33	CPS	−	normal	R	> 75%
Group B	50	m	36	CPS, SG	+	normal	R	100%
	51	f	23	CPS	+	normal	L	100%
	52[2]	f	23	CPS	+	normal	L	100%
	53[1]	f	33	CPS	−	normal	R	> 75%

ST: seizure type; SPS: simple partial seizures, CPS: complex partial seizures; m: male, f: female; Age [years]; MRI normal at the site of the focus/surgery; R: right side, L: left side; DSF: post-surgical decrease of seizure frequency in comparison to pre-surgical seizure frequency; [1]: indicates contratemporal hypoperfusion as seen by rCBF-SPECT; [2]: indicates a right temporal hippocampal lesion (MRI) with a corresponding hypoperfusion (SPECT) but left temporal surgery.

cally all of them were free of seizures. Tc-99m-HMPAO-SPECT was normal in 2 of them and showed temporal hypoperfusion contralateral to the site of surgery in the remaining 2 patients (# 43 and 44). EEG/ECoG, however, showed bitemporal interictal epileptiform potentials in both of them.

In nine patients neither the MRI nor the SPECT were informative and surgery was done only on basis of the EEG and ECoG with good to perfect post-operative reduction of seizure frequency (Table 3d). In two patients (# 48 and 49) the MRI showed discrete abnormalities that were not related to the epilepsy according to the EEG/ECoG. In pt. # 48, who showed a normal rCBF-SPECT, a contralateral slight enlargement of the temporal ventricle system and in pt. # 49 an ipsilateral, but frontal lesion of unclear etiology was seen. In one pt. (# 52) the MRI suggested a hippocampal lesion that corresponded to a hypoperfusion detected by rCBF-SPECT. In pt. # 49 and # 53 rCBF-SPECT showed a temporal hypoperfusion contralateral to the site of the focus. This was interpreted as false-lateralization. Overall in 5 patients (# 49, 52–55) the rCBF-SPECT was interpreted as being falsely lateralized. The MRI detected morphological lesions in 36/55 (65%) and these lesions (MRI) matched to areas of reduced cerebral blood flow (rCBF-SPECT) in 32/55 patients (58%). This, however, means that 89% of all lesions detected by MRI did in fact show a corresponding hypoperfusion in the rCBF-SPECT. In 11% of cases (Table 3c) with morphological lesions, the rCBF-SPECT failed to show a corresponding hypoperfusion and in approximately 8% of these patients the lesions detected by MRI and SPECT were not related to the epilepsy according to EEG/ECoG results (pt. # 52, 54, 55). In 60% of cases the MRI lesion, however, was proved to be the site of the focus on EEG/ECoG basis (Table 3 a and c). Calculated sensitivity for the Gyroscan S15 was 56% and for the Gyroscan ACS II 68%.

The frequency of ECoG application was significantly higher in patients with a normal MRI brain scan (Table 3 b–d) compared to those, who showed a lesion in the MRI which corresponded to the EEG.

The overall sensitivity of interictal rCBF-SPECT was 75% (Table 3 a and b), which reflects 69% sensitivity for low-resolution SPECT systems and 84% for high-resolution SPECT systems. Interictal rCBF-SPECT studies were considered true positive if a hypoperfusion was detected within the temporal lobe that was proven to carry the focus by EEG/ECoG and surgery was consequently done on this side. In 15 patients additional areas of ipsilateral hypoperfusion involving either the frontal or the parietal lobe were detected by rCBF-SPECT. Twelve of these studies were done with low-resolution SPECT systems. If these studies would be considered as non-localizing and therefore false-negative, the calculated overall sensitivity of rCBF-SPECT would be 47%, with 39% for low-resolution SPECT systems and 63% for high-resolution SPECT systems. Lateralization, however, was correct in these patients and no correlation as to a potentially worse post-surgical outcome was found. With respect to this discrepancy of sensitivity, the patients who showed a complete match of MRI/EEG and SPECT (Table 3a) were more closely evaluated in order to establish or to exclude a correlation between the detection of cortical hypoperfusion that exceeded the temporal lobe and the application of ECoG. Cortical hypoperfusion that additionally involved either the ipsilateral frontal or the parietal lobe was seen in nine patients (# 1, 2, 4, 9, 13, 19, 21, 22, 27). In these patients ECoG was applied in 11/29 or 38% of cases and the majority of them (7/11 or 64%) were those who exhibited cortical hypoperfusion that exceeded the temporal lobe. Only 2 patients (# 1 and 13) who showed this kind of disturbed perfusion did not undergo ECoG. In both cases the MRI diagnosis was clear. Due to the lack of true negative studies no specificity was calculated.

DISCUSSION

Surgery for reasons of temporal lobe epilepsy has become a reliable therapeutical approach in patients who are refractory to medical treatment. Since the prevalence of epilepsy is relatively high, there are many patients who might benefit from this therapy.[16] In this retrospective study 94% of patients suffering from temporal lobe epilepsy were free of seizures or at least showed a significantly decreased seizure frequency after surgery. For proper evaluation of the diagnostical abilities of the interictal rCBF-SPECT using Tc-99m-HMPAO, only patients who underwent surgery and in whom post-surgical follow-up data as to seizure frequency were available, were selected. Furthermore the complete results of the presurgical work-up had to be available. Therefore, it is important to notice that a subgroup of patients is presented here. The main inclusion criterion, however, was a post-surgical situation of temporal lobe epilepsy and the rCBF-SPECT did not contribute to making a decision concerning surgery.

The correlation of a morphological pathology detected by MRI with an epileptogenic focus detected by scalp EEG is considered to be the major approach towards epilepsy surgery.[17] In this situation ECoG was only applied in those patients who showed areas of hypoperfusion in the rCBF-SPECT study that extended the temporal lobe. Most patients who showed cerebral hypoperfusion in the temporal lobe only, did not undergo this invasive procedure. The post-surgical seizure frequency was reduced completely or at least significantly in all but one of these patients. This patient developed a local recidive of an oligodendroglioma. If the correspondence of MRI/SPECT and EEG could be established, ECoG was only applied in those patients who showed slight alterations or those which are thought to be nonepileptogenic in the MRI. In general, these findings are in good correspondence with the F-18-DG-PET results described by Engel et al.[18]

In patients with a normal MRI scan the correspondence of EEG and rCBF-SPECT was at least partly used as a guidance for electrode placement. As a bilateral standard implantation scheme, basically consisting of two stereotactically implanted intrahippocampal depth electrodes, each two temporobasal surface stripe electrodes and each one temporolateral surface stripe electrode following the long axis of the temporal lobes, is used for evaluation of temporal lobe epilepsy in our institution, the information derived from the interictal rCBF-SPECT may be limited. However, prior to implantation of temporal electrodes it is important to know weather or not there are additional hints towards non-temporal sites of epileptogenic activity. It is known that especially frontobasal/frontoorbital foci may be difficult to localize using surface EEG, even with the additional application of sphenoidal electrodes. In this situation additional frontal surface electrodes may or may not be applied, at least partly in relation to the results of the rCBF-SPECT.

Earlier studies described a higher sensitivity of interictal F-18-DG-PET compared to interictal rCBF-SPECT and the reports on PET-scanning in epilepsy overall are more consistent than those of rCBF-SPECT. In the largest study to date Henry et al.[19] demonstrated a sensitivity of approximately 65% for F-18-DG-PET using PET-scanners of different resolution and ictal EEG for correlation. They could clearly establish a positive correlation between sensitivity and spatial resolution of the PET scanner. In a selected population of 11 patients with hippocampal sclerosis Valk et al.[20] found a sensitivity of 91% for a high resolution PET system. Still F-18-DG-PET-studies in epilepsy are reported in smaller number compared to rCBF-SPECT studies and special clinical situations like childhood epilepsy or frontal lobe epilepsy or both together are not evaluated with F-18-DG-PET in larger numbers of patients.

It has been shown that rCBF and rCGU are closely linked in most clinical situations and only for certain postictal periods it is discussed that there might be a temporary uncoupling of blood flow and metabolism.[21,22] Therefore, the main factor for sensitivity is considered to be spatial resolution, if the two relatively wide-spread procedures F-18-DG-PET and rCBF-SPECT are compared and recent reports claimed that modern SPECT systems dedicated for brain SPECT have largely filled the described gap of sensitivity between PET and SPECT.[12]

In this study sensitivity of interictal rCBF-SPECT increased from 69% for low spatial resolution SPECT systems to 84% for moderate- to high-resolution SPECT systems. The advanced MRI system also showed increased sensitivity. This was considered to be mainly due to its ability to perform fast high-resolution sequences at a very thin slice thickness. Using T2-weighted TSE-sequences hippocampal atrophy and sclerosis were almost perfectly detectable.

If the performance of the advanced MRI and SPECT systems are compared to the results of the older systems, a shift can be seen towards a clearer detection of pathology in this study. The interictal rCBF-SPECT showed good correlation of EEG and MRI in 42% of patients, if low resolution systems were used. High resolution SPECT systems, however, showed a complete match including MRI and EEG in 74% of cases. Using this equipment no cases were seen in whom the MRI detected a lesion that corresponded to the EEG and the rCBF-SPECT was normal. Using the Gyroscan S15 33% of studies were normal, but only 26% of studies were normal in those patients who were evaluated with the Gyroscan ACS II. These numbers also are in good correspondence with the MR-literature.[2,5]

Given the thesis that interictal hypoperfusion as seen by rCBF-SPECT reflects a morphological lesion and the additional dysfunctional influence of this lesion to related cortical areas,[23] the good correlation of rCBF-SPECT and MRI in this study and furthermore the higher sensitivity of the interictal rCBF-SPECT compared to the MRI can be explained.[24] A limitation of both procedures still is, that the epileptogenity of a detectable lesion must still he proven and furtheron, if the seizure focus originates in the vicinity of the lesion, the precise site and extend of the focus is not necessarily the same as that of the lesion. The latter may primarily be considered a problem for MRI as interictal rCBF-SPECT studies often show relatively large areas of hypoperfusion. The limited specificity of MRI and rCBF-SPECT in epilepsy is clearly seen in those patients who presented a corresponding lesion in both procedures, but EEG proved the focus to be elsewhere. Although being considered a functional imaging method, the data presented in this study clearly show a relationship of interictal rCBF-SPECT and MRI. This may be one reason for so called false-lateralizations of rCBF-SPECT.[25] In this population 9% of SPECT-studies were considered as being falsely lateralized using Tc-99m-HMPAO and the same phenomenon was seen in 7% of the MRI-studies. Furthermore, as rCBF-SPECT—so far—is not able to provide absolute quantification, subclinical epileptogenic activity may result in a relative hyperperfusion ipsilateral to the site of the focus, but might rather be interpreted as contralateral hypoperfusion, if the interpretation of the scan is focussed on asymmetrical cortical uptake. This may be avoided, if the injection is given under EEG-control, which was not done in this study.

Under surgical aspects, however, the detection of a morphological lesion must still be considered a major advantage, if a correlation with the surface EEG can be established. ECoG may be avoided in this situation if the rCBF-SPECT shows a hypoperfusion that is limited to the ipsilateral temporal lobe. This corresponds well to results described tor CGU-PET.[26,27] Furthermore, it might change the strategy of ECoG if neither the EEG or the MRI present convincing results. It is additionally of value, if the application of ECoG is intended in patients with a normal MRI brain scan. In a time of rising concerns about the costs of diagnostic procedures, the interictal rCBF-SPECT has proven to provide appropriate sensitivity compared to CGU-PET, if high-resolution SPECT systems are available.

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