MR Measurement of Regional Relative Cerebral Blood Volume in Epilepsy

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Introduction: A precise localization of the epileptogenic zone is crucial for a planning of surgical treatment. Modern neuroimaging techniques in combination with EEG have been applied for the detection of epilepsy foci (1). Since the establishment of cerebral hemodynamic studies using MR susceptibility effects (2,3), there has been a growing interest in the MR study of regional relative cerebral blood volume (rCBV) for various brain lesions. In epilepsy, the development and application of MR rCBV maps has considerable potential benefits such as multiplanar acqusition, high spacial resolution, and lack of radiation. However, use of this technique has not been investigated in this population to date. In the present study, we applied MR rCBV maps for studying regional hemodynamic changes in interictal patients and one ictal epilepsy patient.

Materials and Methods: Ten patients were included in this study. Nine patients with temporal lobe epilepsy (TLE) were investigated interictally. One patient with a unilateral epileptic status was examined during the status. All patients were examined with a superconducting 1.5-T scanner (Vision, Siemens). Conventional T1-weighted images and PD/T2-weighted images were obtained in angulated coronal slices which were perpendicular to the lang axis of the temporal lobe. The dynamic slice was chosen in the identical slice position of the T2-weighted images. In the nine interictal TLE patients, a T2*-weighted fast low-angle shot (FLASH) sequence was used. These FLASH sequences were acquired parallel to the T2-weighted images. Because of multiple frontal and parietal lesions on T2-weighted images in the ictal patient, the dynamic plane was defined axially using a spin echo echo-planar imaging (EPI) multislice sequence. Gadopentetate dimeglumine (0.2 mmol/kg) was injected following baseline acquisition. The bolus of gadopentetate dimeglumine was rapidly injected with a flow rate of 5 ml/second with a power injector (Medrad Spectris, Pittsburgh, USA), followed by a 15 ml saline flush. After each MR examination, the dynamic data were transferred from the MR to a remote SUN Sparc 20 workstation. Image processing of dynamic raw data was performed on a pixel-by-pixel basis. In 8 (7 interictal patients) of the 10 patients , cerebral PET with [18F] fluorodeoxyglucose (FDG) was carried out. Reconstructed regional rCBV maps and conventional T1 and T2 weighted MR images in identical positions were analyzed and compared to the PET results. The ROIs were outlined using an interactive computer display. Regional rCBV were measured in the hippocampus of both hemispheres.

Results: The findings of interictal TLE patients are summarised in Table.

Table. Abnormal findings in the interictal temporal lobe epilepsy patients

patient	difference of rCBV between two sides	hippocampus atrophy	PET hypometabolism
1. R.P.	72%	left	left hippocamps
2. P.T.	86%	left	left hippocamps
3. M.C.	58%	left	left hippocamps
4. G.M.	84%	no	left hippocamps
5. A.S.	92%	left	left hippocamps
6. W.R.	88%	left	not available
7. W.S.	73%	left	left hippocamps
8. S.M.	52%	right	right hippocamps
9. W.J.	57%	right	not available

In 7 of the 9 interictal cases, lower rCBV of the left hippocampus was observed by MRI and confirmed by PET, if performed. The mean ratios of regional rCBV were 1.96 (left hippocampus / white matter) and 2.49 (right hippocampus / white matter). The difference of the mean ratios was statistically significant (p=0.01, paired Student t test). In 1 of the 7 patients, there was no abnormal finding on conventional MR imaging. Left hippocampal atrophy, an indicative of hypocampal sclerosis, was found in 6 of the 7 cases on conventional images. Lower rCBV in left parahippocampal and occipitotemporal gyri can be also observed in the cases with hippocampal atrophy . Figure 1 illustrates a representative case. In 2 of the 9 interictal TLE patients, lower rCBV areas were observed in right hipocampus.

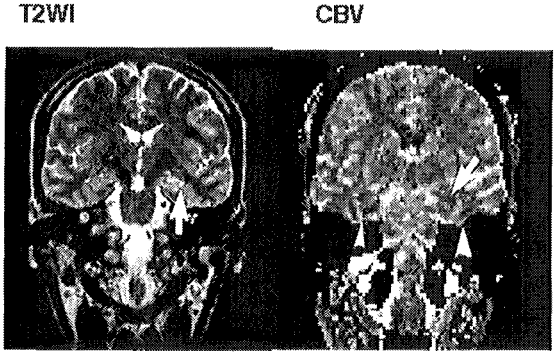

Fig. 1. Interictal TLE. a. Slight atrophy in left hippocampus (arrow) on T2WI. b. CBV map shows reduced rCBV in the left hippocampus (arrow) and parahippocampal and occipitotemporal gyri (large arrowhead) compared to other side (small arrowhead).

In the ictal case, T2-weighted images showed hyperintensity lesions in frontal and parietal lobes (Fig. 2a). The regional rCBV map demonstrated increased blood volume in the lesions (Fig. 2b). A brain PET scan also showed marked hypermetabolism of the right frontal and parietal regions.

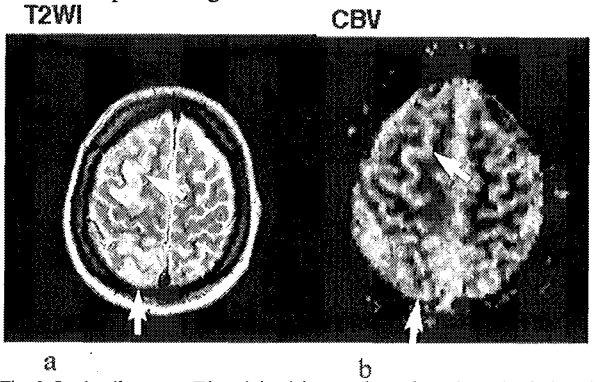

Fig. 2. Ictal epilepsy. a. T2-weighted image shows hyperintensity lesions in frontal and pariental lobes (arrows). b. Relative rCBV map. Increased rCBV areas in right frontal and pariental lesions (arrows).

Conclusion: The present results indicate that regional hemodynamic changes in temporal lobe epilepsy can be evaluated by dynamic contrast-enhanced MR imaging. Regional rCBV maps are sensitive in detecting epileptic seizure foci. Decreased rCBV in interictal focuses can be demonstrated. In the patients studied during seizures both PET and rCBV-MRI showed an elevation of metabolic parameters. MR based regional rCBV maps have the potential to facilitate selection of surgical candidates in epilepsy patients.

References

1. Spencer, S.S., Theodore, W.H., Berkovic, S.F., *Magn Reson Imaging,* 13, 1119, 1995.

2. Rosen, B.R., Belliveau, J.W., Vevea, J.M., Brady, T.J., *Magn. Reson.Med.,* 4, 249, 1990.

3. Belliveau, J.W., Rosen, B.R., Kantor, H.L., Rzedzian, R.R., Kennedy, D.N., McKinstry, R.C., Vevea, J.M., Cohen, M.S., Pykett, I.L., Brady, T.J., *Magn. Reson. Med.,* 14, 538, 1990.