Dynamics of ictal and postictal brain diffusion and perfusion

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Synopsis

Focal alterations in the epileptogenic zone have been demonstrated by diffusion-weighted MR-imaging (DWI) following focal status epilepticus. This study tested the hypothesis that dynamic spatio-temporal alterations of brain diffusion and perfusion during the immediate postictal state will be detectable by serial DWI and perfusion weighted imaging (PWI) in extra- (ETE) and temporal lobe epilepsy (TLE). Serial postictal DWI and PWI changes appear to reflect origin and spread of the preceding seizure. A delineation of the epileptogenic zone appears to be possible.

Introduction

10 to 20 percent of patients with epilepsy do not respond to pharmacological treatment. In these patients, surgery is a valid and powerful therapeutic option. So far, diagnostic procedures comprise PET or SPECT and invasive EEG for presurgical evaluation. The objective of this study was to detect 1) the side of the epileptogenic focus and to depict 2) regional alterations of brain perfusion and diffusion during epileptic seizures and 3) during the immediate postictal state in patients with ETE and TLE using MRI.

Patients and Methods

We examined 6 patients (23 – 47 y/o, mean 32), 4 with TLE and one with ETE and one with TLE and ETE using a 1.5T MRI (Siemens Sonata). Scans were performed 2-50 minutes postictally and repeated serially up to 240 minutes. DWI and PWI were acquired in the coronal plane covering the temporal lobes. From DWI (TE=83 ms, TR=5000 ms, b=0, 500, 1000 s/mm²) ADC values were calculated and an anatomically based region-of-interest (ROI) analysis of the temporal lobe and the gray and white matter (control regions) of the ictal and contralateral hemisphere was performed. Perfusion data (TE = 45ms, TR = 1500 ms, Matrix = 128x128, 8 slices, 60 acquisitions) were postprocessed with MEDx (Sensor Systems, Sterling,VA, USA) to assess cerebral blood volume (CBV), cerebral blood flow (CBF), bolus peak ratio (BPR) and mean transit time (MTT) including motion correction and deconvolution with the arterial input function. As a semiquantitative measure we used an asymmetry-index comparing ictogenic with non-ictogenic side. Postictal examinations were compared to interictal (baseline) reference scans of the same patient.

Results

DWI: Patients with temporal lobe sclerosis showed an ADC increase interictally in the focal hippocampus when compared to the non-ictogenic side. Postictally the ADC decreased by 20-35% on the ictogenic side and returned to base-line during the following hours. The time course of ADC varied with the length and severity of the seizures. On the non-ictogenic side and in control regions (thalamus, precentral white matter) only minor ADC-changes were seen. PWI: Baseline (interictal) BPR of the AH was elevated (>1) in 5/6 patients on the ictogenic side. In all patients BPR decreased up to 61% (mean 37%) within 22-55min postictally possibly indicating relative hypoperfusion on the ictogenic side. In 4 patients with late postictal measurements, a return of BPR back towards baseline could be observed. In patients with TLE rCBV in the mid-hippocampus (AH) declined in the immediate postictal phase by maximally 36- 64%. In contrast, rCBF increased by approximately 79% in 2/6 patients (ETE + TLE). rCBF decreased during the first 55 min in all patients, except in 1 patient. Baseline BPR in the parahippocampal gyrus (PHG) was elevated (> 1) on the ictogenic side in 5/6 patients. BPR increased in 5/6 patients by 22-92% during the first 55 min. Increases of the rCBV on the ictogenic side were seen in all patients during the first postictal hour. PWI: Baseline BPR in the parahippocampal gyrus (PHG) was elevated (> 1) on the ictogenic side in 5/6 patients. BPR increased in 5/6 patients by 22-92% during the first 55 min. Increases of the rCBV on the ictogenic side were seen in all patients during the first postictal hour.

Discussion

These preliminary findings of serial imaging of brain diffusion and perfusion in ETE and TLE demonstrate the feasibility of the presented methods. Serial postictal DWI changes seem to reflect origin and spread of the preceding seizure. As previously shown by the immediate postictal SPECT, the ictogenic AH seems to be relatively hypoperfused postictically. However, in contrast to previous findings, the following findings were made here: 1. the sclerotic hippocampus appeared to be hyperperfused interictally. 2. Shifts in BPR indicated substantial hyperperfusion of the PHG immediately postictal. 3. Even though remote from the initial epileptogenic zone the cortex on the ictogenic side and the thalamus seemed to go through periods of hypoperfusion postictically. 4. The WM depicted a period of relative hyperperfusion on the ictogenic side. One has to keep in mind though that all of the perfusion findings are semiquantitative and relative since they are based on comparison of homotopic brain areas of the ictogenic versus the non-ictogenic side. Further studies are needed to evaluate the spatio-temporal relationship of dynamic postictal DWI and PWI changes. At present, DWI and PWI may be utilized as a lateralizing tool in presurgical evaluation of TLE.

References