Interictal arterial spin-labeling MRI perfusion in intractable epilepsy

IRM interictale de perfusion par marquage des protons dans l’épilepsie pharmacorésistante


Department of Neuroradiology, Geneva University Hospital, Switzerland
Department of Nuclear Medicine, Geneva University Hospital, Switzerland
Department of Radiology, Geneva University Hospital, Switzerland
Department of Psychiatry, University of Bern, Switzerland
Department of Neurology, Geneva University Hospital, Switzerland
Department of Neurosurgery, Geneva University Hospital, Switzerland

Available online 11 August 2009

KEYWORDS
Arterial spin-labeling; MRI; Perfusion; Epilepsy; Temporal lobe

Summary
Introduction. — Magnetic resonance imaging (MRI) is required for the investigation of surgically intractable epilepsy. In addition to the standard MRI techniques, perfusion sequences can be added to improve visualization of underlying pathological changes. Arterial spin-labeling (ASL) MRI perfusion does not require contrast administration and, for this reason, may have advantages in these patients.

Methods. — We report here on 16 patients with epilepsy who underwent MRI of the brain with ASL and positron emission tomography (PET).

Results. — Despite a slightly reduced resolution with ASL, we found a correlation between ASL, PET and electrophysiological data, with hypoperfusion on ASL that corresponded with hypoperfusion on interictal PET.

Conclusion. — Given the correlation between ASL and PET and electrophysiology, perfusion with ASL could become part of the standard work-up in patients with epilepsy.

© 2009 Elsevier Masson SAS. All rights reserved.

Introduction

Imaging plays a major role in the management of patients with epilepsy [1,2]. Seizures are a frequent symptom in such patients and, while pharmaceutical therapy remains the first line of approach, patients can develop pharmacologically
refractory seizures that may necessitate surgery. Thus, it is important to further improve the diagnostic armamentarium that can be used in these patients. Perfusion techniques are usually employed as an adjunct to anatomical sequences in Magnetic resonance imaging (MRI). As arterial spin-labeling (ASL) requires no contrast use, it is of considerable interest [3–6]. We report here on patients who underwent MRI with additional ASL.

Patients and methods

In the present study, which was approved by our local ethics committee (study number: 08-097 R [NAC 08-031R]), we examined 16 patients (10 males, six females; ages 7–55 years) with intractable epilepsy who were referred to our epilepsy presurgical work-up unit for evaluation of intractable seizures. In this unit, patients are seen by a multidisciplinary team comprising neurologists, neurosurgeons, neuroradiologists and pediatricians specializing in the work-up of patients with epilepsy. In addition to a full clinical examination, our 16 patients underwent non-invasive electroencephalography (EEG). On the basis of their clinical and electrophysiological findings, nine patients had temporal lobe epilepsy, two had post-traumatic scar lesions, three had focal seizures and two had dysplastic lesions with secondary epilepsy.

MRI was performed using a 3.0-T Magnetom Trio (Siemens; Erlangen, Germany) (Figs. 2 and 4). ASL was performed with a pulsed sequence, using a QUIPSII perfusion mode and the following parameters: 16 slices; voxel size: 3.4 × 3.4 × 6 mm; TA = 5:55 min; lambda = 0.9 mL/g; alpha = 95%; and TE/TR/T1/T12/T1 (blood 3T) = 15/5000/700/1800/1496,19 ms. Relative cerebral blood flow (relCBF) maps for ASL were calculated online by the MRI scanner, and offline for contrast-enhanced perfusion-weighted imaging (cePWI) using Syngo Perfusion (MR) software.

An epilepsy protocol was used, comprising the following sequences: axial T2-weighted images (TE: 101 ms, TR 4000 ms, 26 slices, 4-mm thickness, 372 × 510 matrix); sagittal T1-weighted multiplanar reconstructed (MPR) (TE: 2.32 ms, TR: 1900 ms, 512 × 512 matrix) and sagittal threedimensional fluid-attenuated inversion recovery (3D FLAIR) (TE: 420 ms, TR: 6000 ms, 256 × 256 matrix, 162 1-mm thick contiguous images).

Susceptibility-weighted imaging (SWI) was performed, using 3D acquisition with an in-plane resolution of 1 × 1 × 1 mm, as well as diffusion-weighted imaging (DWI) with 30-direction scanning.

Interictal [18F]-2-fluoro-deoxy-o-glucose positron emission tomography with computed tomography ([18F-FDG PET/CT) was used for comparison with ASL as it is known to have better spatial resolution and greater sensitivity for correct localization of epileptogenic regions compared with interictal nuclear-medicine perfusion imaging techniques such as 99m-technetium ethylcysteinate dimer single-photon emission computed tomography (99mTc-ECD SPECT). Thirty minutes after intravenous injection of a mean dose of 169 ± 27 MBq of 18F-FDG, integrated PET/CT was acquired, using a Siemens Biograph 16, after CT without contrast enhancement (2-mm slices) for anatomical co-registration, attenuation and scatter correction. As well as visual evaluation, the FDG PET scans were compared with a normal series from 12 healthy subjects to identify clusters of voxels showing statistically significant (∗∗P < 0.05) hypometabolism.

Results

The ASL perfusion maps showed multiple areas of hypoperfusion that corresponded well with the hypometabolic areas seen on the PET images. All cases with temporal lobe epilepsy (TLE) showed hypoperfusion in the affected temporal lobe on both the interictal PET and ASL maps (Figs. 1–3). In those cases where a cortical lesion was visible on imaging and corresponded with an alteration seen on PET, the same result was also seen on ASL perfusion (Fig. 4). In general, although the ASL images showed slightly poorer spatial resolution, they provided an equal amount of information.

Discussion

The perfusion maps we obtained with ASL corresponded well with the PET perfusion and EEG results in patients with intractable epilepsy. These patients were also candidates for eventual surgery; this is not surprising because, while PET with FDG represents metabolic activity, ASL perfusion provides maps of cerebral blood flow, another parameter of perfusion.

Whenever patients with intractable epilepsy—seizures that cannot be controlled even with complex pharmacological combination therapies—are investigated, it is necessary to consider surgery as a possible option. In such patients, the precise localization of seizures is carried out by both electrophysiology as well as neuroimaging studies. This has confirmed on MRI an important role in
the anatomical evaluation of these lesions. While traditional MRI techniques can provide anatomical information, nuclear-medicine techniques are relied upon to visualize brain perfusion both ictally and interictally. This means that new MRI techniques, such as diffusion and perfusion, are now becoming part of the standard care of such patients.

In the present study, we found a correspondence between interictal and ictal findings: the interictal lesions showing hypoperfusion on PET also showed hypoperfusion on ASL perfusion. Indeed, ictal ASL findings were found to correlate with ictal PET in a study of a patient with hemimegalencephaly and epilepsy [7]. In addition, we also show that ASL can be used for the evaluation of interictal lesions of various types — not just in TLE, but in developmental disorders as well [8].

For these reasons, imaging plays a crucial role in any investigations [8], and adding ictal and interictal perfusion information has been shown to be essential in the evaluation of epilepsy, where nuclear-medicine methods — especially the SISCOM (subtraction ictal SPECT co-registered to MRI) technique — are the standard imaging procedures. As for interictal perfusion imaging, its findings have already been well established.

Given that ASL offers visualization of flow values and not metabolism, it may represent a better means of visualizing interictal hypoperfusion in patients with epilepsy. In addition, ASL does not require the use of intravenous contrast agents, which is an advantage in the case of young patients and/or in those who may have renal impairment. It is also advantageous for patients in whom standard ictal perfusion imaging cannot be performed, and in those cases where interictal examinations may have to be repeated often. The latter is of particular interest, given the current concerns over the potential for the development of systemic nephrogenic fibrosis with exposures to some contrast media. Thus, we believe that adding brain perfusion investigations to the MRI protocol in patients with intractable epilepsy may have a number of advantages.

References


