Arterial Spin Labeling Cerebral Perfusion Magnetic Resonance Imaging in Migraine Aura: An Observational Study

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Background: Changes in cerebral perfusion during migraine with aura (MA) have been assessed mainly using dynamic susceptibility contrast (DSC) magnetic resonance perfusion imaging. A contrast agent-free method to assess these changes would be desirable. We assessed changes in cerebral perfusion during MA using arterial spin labeling (ASL) perfusion magnetic resonance imaging. *Methods:* We investigated 4 patients with a standardized protocol including ASL perfusion imaging during MA (n = 2) or early headache phase (n = 2) and asymptomatic follow-up. Semiquantitative evaluation was done using a region of interest (ROI) within hypoperfused or hyperperfused areas and corresponding ROIs in the contralateral hemisphere. Relative ratios of mean perfusion in the corresponding ROIs were calculated. DSC imaging was done at initial time points and compared visually with ASL findings. *Results:* In all patients, regional perfusion changes were detected in the acute phase. These abnormalities did not respect the boundaries of major cerebral vascular territories but overlapped onto adjoining regions. During MA, adjacent hypoperfused and hyperperfused areas were found, whereas during headache, regional hyperperfusion only was observed. Perfusion abnormalities normalized on follow-up. *Conclusions:* ASL perfusion imaging is a contrast agent-free method suitable for assessment of reversible perfusion changes during or immediately after MA. **Key Words:** Migraine disorders—perfusion magnetic resonance imaging—arterial spin labeling—arterial transit artifact.

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Background

Migraine with aura (MA) is a common disorder presenting with focal neurologic signs typically followed by hemicrania. Cortical spreading depression has been used as a model of the underlying pathophysiology of MA. Cortical spreading depression has been described as a "spreading wave" of neuronal depression that causes aura symptoms.[1]

The first evidence of regional oligemia followed by hyperemia in MA was provided in the 1980s.[2,3] Using magnetic resonance imaging (MRI), regional hypoperfusion during MA employing dynamic susceptibility contrast (DSC)-enhanced sequences has been reported.[4-6] A few cases involving regional hyperperfusion in DSC imaging after prolonged MA have also been reported.[7]

Arterial spin labeling (ASL) MRI (thereafter termed "ASL") has been developed to measure cerebral perfusion without application of gadolinium-based contrast agent. This method has been used to detect hypoperfused or hyperperfused brain tissue in patients with ischemic stroke. More recently, cases describing regional perfusion changes as assessed by ASL during MA have been reported.[8-11] However, studies focusing on ASL in migraine are scarce.

We report on 4 patients with acute MA who underwent ASL perfusion imaging during aura (n = 2) or headache (n = 2) and asymptomatic follow-up. At the initial investigation, additional DSC perfusion imaging was carried out.

Patients and Methods

Patients

The study was approved by the ethics committee of our hospital. Patients with acute onset of neurologic symptoms suggesting hemispheric stroke or a stroke mimic were examined by 3-T MRI as soon as possible using a standardized imaging protocol (including ASL perfusion) as described previously.[12] In 4 patients (3 women, 1 man, mean age 37 [range 32-43] years), the final diagnosis of acute MA was established based on clinical and imaging criteria. Two patients were investigated during MA and the remaining 2 patients during the early-headache phase immediately after MA (Table 1A).

Imaging

Imaging was undertaken on a 3-T Skyra or Trio (Siemens, Munich, Germany) system. ASL measurements were obtained using a Q2TIPS-FAIR single-shot 3-dimensional gradient and spin echo[13] readout (repetition time/echo time: 3000/13.2 ms; inversion time: 2300 ms; acquisition time: 96 seconds). Follow-up MRI was carried out in all patients when they were asymptomatic.

Data Analyses

After visual analyses of ASL maps to identify hypoperfused or hyperperfused brain tissue, regions of interest (ROIs) were delineated manually in respective areas. Corresponding ROIs in the contralateral hemisphere were identified and selected. To assure an optimal corresponding match, ROIs were placed symmetrically with reference to the interhemispheric gap. For semiquantitative analyses, relative ratios (RRs) of mean perfusion in regions with conspicuous perfusion compared with contralateral normal areas were calculated. RRs were calculated as mean perfusion in the ROI on the symptomatic side divided by the mean perfusion in the ROI on the contralateral normal side. Follow-up imaging was co-registered with initial scans, and identical areas were analyzed by superimposing baseline ROIs on these follow-up scans. RRs for follow-up scans were calculated in the same manner as for the initial scans. If DSC perfusion was available, time-to-peak perfusion maps were analyzed visually, and the distribution of perfusion abnormalities was compared with ASL perfusion patterns.

ASL maps were analyzed further visually because of the potential occurrence of an arterial transit artifact (ATA). A filiform hyperintense signal corresponding to the course of the branch of an intracranial artery was searched for in conspicuous regions.

Results

Regional perfusion changes were detected in all 4 patients. These changes did not respect the boundary of major cerebral vascular territories but overlapped onto adjoining regions. This finding contrasts to typical observations in ischemic stroke, in which perfusion changes match vascular territories. During MA, adjacent hypoperfused and hyperperfused areas were found in both patients, whereas in those 2 patients who were examined during the headache phase, regional hyperperfusion only was observed (Fig 1). ROI analyses of ASL maps (Table 1B) showed RRs of 1.41-2.32 in hyperperfused areas normalizing at follow-up (RR = 1.02-1.51); initial hypoperfusion (RR = .42-.62) was reversible (RR = .99-1.24). An ATA was present in both patients with hypoperfusion, and resolved at follow-up. Visual analyses of initial DSC perfusion showed similar perfusion changes as those found on ASL imaging.

Details of the clinical presentation and course are summarized in Table 1A. Aura symptoms comprised isolated visual disturbance, visual disturbances and hemihypesthesia, hemihypesthesia and hemiparesis, as well as aphasia combined with hemiparesis. Duration of aura symptoms varied between 45 minutes and 3 hours.

Discussion

We describe 4 patients with acute MA who underwent ASL perfusion imaging during MA or early headache