CASE REPORT

Arterial spin labeling shows cortical collateral flow in the endovascular treatment of vasospasm after post-traumatic subarachnoid hemorrhage

Technique de perfusion par marquage des spins pour l’étude du flux collatéral cortical après traitement endovasculaire du vasospasme post-traumatique

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Summary  We report here on the case of a patient who, 10 days prior to his admission to hospital, had suffered a bicycle accident. He presented with signs of minor dysphasia. A brain CT-scan revealed slight subarachnoid hemorrhage (SAH) in the left sylvian fissure as well as narrowing of the distal M1 segment of the left middle cerebral artery (MCA) on CT-angiography. MRI showed diffusion abnormalities and hypoperfusion in the left MCA territory with cortical hyperperfusion on arterial spin labeling (ASL). Arteriography confirmed the vasospasm, but showed no sign of aneurysm. Angioplasty of the narrowed MCA was successful, and follow-up MRI showed reperfusion of the MCA territory.

Introduction

Cerebral vasospasm following subarachnoid hemorrhage (SAH) is a cause of delayed neurological dysfunction associated with morbidity and mortality [1]. While mostly seen following aneurysmal rupture, it can also occur post-traumatically [2–5]. It is usually diagnosed by diagnostic
Arterial spin labeling in the endovascular treatment of vasospasm, although the overall trends tend to favor other, less invasive, methods for its detection and monitoring such as ultrasound, computed tomography angiography (CTA) or magnetic resonance angiography (MRA) [6,7]. MR diffusion and perfusion techniques have also been applied to cerebral vasospasm with some success, but a major drawback is their inability to demonstrate collateral flow [8]. However, in any event involving cerebral ischemia, the presence and detection of collateral flow is of primary importance and, until now, this has mainly only been possible with digital subtraction angiography (DSA).

Now, a relatively new MR method—perfusion with arterial spin labeling (ASL)—should be able to detect collateral flow. We describe here a case in which a patient presented with signs of vasospasm and was investigated using multimodal techniques.

Case report

This 24-year-old male patient had suffered bicycle-accident trauma 10 days prior to being admitted to hospital. He had been wearing no protection and briefly lost consciousness. He reported a left-sided headache along with signs of slight dysphasia: he had trouble finding the right words. The pupils of his eyes were symmetrical, and he presented with no sensory or motor deficits. He was first referred to CT, then magnetic resonance imaging (MRI) and, finally, angiography—all on the same day.

CT was performed on a 16-slice scanner (Fig. 1). Initially, the images were unenhanced and followed by CTA. For CTA, contrast was administered using a cubital approach and a MEDRAD injector. Spiral acquisition was performed from the aortic arch up to the circle of Willis. Finally, axial postcontrast images were acquired.

MRI was performed on a 3.0-T Magnetom Trio (Siemens; Erlangen, Germany) (Figs. 2 and 3). ASL was performed with a PASL sequence, using a QUIPSII perfusion mode and the following parameters: 16 slices; voxel size: $3.4 \text{ mm} \times 3.4 \text{ mm} \times 6 \text{ mm}$; $\lambda = 0.9 \text{ mL/g}$; $\alpha = 95\%$; and $TE/TR/TI1/TI2/T1 (\text{blood 3T}) = 15/5000/700/1800/1496$, 19 ms. Relative cerebral blood flow (relCBF) maps for ASL were calculated by the MRI scanner, and contrast-enhanced perfusion-weighted imaging (cePWI) with the use of Syngo perfusion (MR) software. Susceptibility-weighted imaging (SWI) was performed using 3D acquisition with an in-plane resolution of $1 \text{ mm} \times 1 \text{ mm} \times 1 \text{ mm}$. In addition, cePWI was acquired as well as DWI through a 30-direction scan.

Angiography was performed via a femoral approach (Fig. 4) under local anesthesia. The high-volume injection for cerebral parenchymography from the aortic arch was significantly delayed in terms of parenchymal perfusion of the left middle cerebral artery (MCA) territory. Selective left internal carotid artery injection revealed severe vasospasm at the level of the supraclinoid carotid, and M1 and M2 seg-

Figure 1 (A): cerebral computed tomography (CT) performed 10 days after trauma. On unenhanced images, high-density values in the left sylvian fissure are visible; (B): on CT angiography, the left MCA is poorly visualized compared with the contralateral side.

Figure 2 Brain MRI performed on the same day as CT. Diffusion imaging shows hyperintensities in the left insular region (A) with slightly decreased ADC values (B). On the contrast-enhanced T1-weighted image, the cortical vessels in the left hemisphere are hyperintense due to their decreased flow (C). The arterial spin-labeling (ASL) map shows hypoperfusion in the left MCA territory with increased collateral flow (D). Asymmetrical flow in the MCA is also visible on the 3D time-of-flight (TOF) MR-angiography sequence (E). SAH is evident on both the T2* and SWI images (F, G).
Figure 3  The patient’s final MRI shows reperfusion and no MCA hypoperfusion on ASL (A), and a limited ischemic lesion on the corresponding T2-weighted image (B).

Figure 4  Digital subtraction angiography (DSA) reveals a vasospasm of the left MCA (A), but no aneurysm. Intracranial angioplasty was performed (B) with good anatomical results (C).

ments of the MCA. Balloon angioplasty was then performed, with a good result on angiography.

Following the intervention, the patient was hospitalized for 15 days, during which time his dysphasia regressed, leaving him with slight word-finding problems, but considerably less than initially.

Discussion

Cerebral vasospasm after trauma remains a relatively rare event; the literature reports wide variations in its incidence. Non-traumatic and posttraumatic vasospasms have been evaluated by many modalities in addition to the conventional angiographic methods. Indeed, ultrasonography, CT and MRA have all been described in its evaluation. The advantage of MRI, however, is its inherently high tissue contrast and ability to demonstrate ischemia through a combination of sequences such as diffusion and perfusion. Given their physics, however, the conventional contrast-based MR perfusion techniques can only reliably demonstrate CBF losses, not increases.

ASL is a promising, non-contrast-based, brain-perfusion technique that offers the possibility of obtaining CBF maps that cover the entire brain. It has also been postulated to demonstrate collateral flow better than with other techniques. Furthermore, we have demonstrated the usefulness of ASL in detecting the presence of hyperperfusion due to collateral flow in addition to the hypoperfusion seen with MR perfusion using contrast. This is in agreement with recent reports that cortical collateral flow can be adequately assessed by ASL [9-10].

Thus, although the present report represents only one case, it clearly shows that ASL can provide information consistent with DSA in terms of the presence of collateral cortical flow, which is protective. Thus, ASL offers information on the cerebral circulation that is important when dealing with patients suffering from an ischemic event [11].

References


