MR Regional Perfusion Imaging: Visualizing Functional Collateral Circulation

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CASE REPORT

MR Regional Perfusion Imaging: Visualizing Functional Collateral Circulation

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SUMMARY: We applied regional perfusion imaging (RPI), a new arterial spin-labeling MR imaging method that selectively studies regions of the brain perfused by individual carotid and basilar arteries. In a patient with cerebrovascular disease, RPI showed cerebral tissue perfused by pial collateral vessels, thereby demonstrating the relationship between anatomic and functional information, which was lacking in conventional x-ray angiography. RPI may be useful to study functional collateral circulation and hence guide therapy in ischemic disease.

Although the collateral circulation is an important determinant of clinical outcome in patients with cerebrovascular occlusion, current methods of evaluation are limited.[1-4] We report regional perfusion imaging (RPI), a noninvasive arterial spin-labeling (ASL) MR imaging method that can visualize collateral brain tissue perfusion.

Case Report

A 50-year-old man with no significant history had slurred speech and left-sided weakness. Five days after onset, he underwent combined MR imaging examination in a 3T clinical scanner (Intera; Philips Medical Systems, Best, the Netherlands) with an 8-element parallel imaging-compatible phased-array head coil as part of an institutional review board–approved study. Diffusion-weighted MR imaging (DWI) showed acute infarction of the right corona radiata (Fig 1*A*), and MR angiography (MRA) revealed right middle cerebral artery (MCA) occlusion (Fig 1*B*). On the basis of the MRA, RPI was performed by placing selective labeling slabs for ASL over the left internal carotid artery (ICA) (*green box*, Fig 1*B*), right ICA, and basilar arteries in turn, by using a single-shot echo-planar imaging sequence (TR/TI/TE = 4000/1500/9.2 ms; spin-echo acquisition and sensitivity encoding factor = 3; matrix = 64 × 64; 60 dynamics; 9 sections; section thickness = 6 mm; scanning time = 3 perfusion territories × 4 minutes = 12 minutes).[5] The 3 RPI territories were combined into 1 image for evaluation, with the left ICA colored green; the right ICA, red; and posterior circulation colored blue (Fig 1*C*). The ischemic right MCA territory received perfusion from the right anterior cerebral artery (in red) and from posterior circulation collaterals (in blue). X-ray angiography confirmed the pial collateral supply (Fig 1*D*). The area not supplied by any vascular territory (*arrows* in *C*) corresponded to a region of decreased vascular reserve on acetazolamide challenge single-photon emission CT (SPECT) (Fig 1*E*). The patient was treated with aspirin and underwent successful right external carotid-to-internal carotid artery bypass and recovered with full motor power.

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Discussion

Regional perfusion imaging by using an ASL method developed for 3T MR imaging scanners can provide functional information about both collateral blood supply and brain tissue perfusion. Various brain perfusion imaging techniques have been used to evaluate the hemodynamics in patients with cerebrovascular disease.[6-9] The difference (or mismatch) between abnormal areas on DWI and perfusion MR imaging studies may represent the potentially salvageable ischemic tissue at risk of infarction and has been used to target patients for thrombolytic therapy.[10] However, the definition of hemodynamically significant arterial stenosis must also take into account the protective effect of collateral circulation, which influences final infarct size and clinical outcomes.[1-3] Unfortunately, current methods of assessing collateral circulation by using x-ray angiography are invasive and are typically not performed in patients with acute stroke. A noninvasive method that incorporates functional information into perfusion MR imaging studies to better characterize the role of collaterals in therapeutic and prognostic applications would, therefore, be desirable.[1]

In the patient we described, RPI could provide functional information about both collateral blood supply and brain tissue perfusion. By exclusively labeling the spins within individual intracranial arteries, we can selectively measure the regions of the brain perfused by each artery, including the territories supplied by collateral circulation.[11,12] This process of individual labeling is conceptually similar to x-ray angiography, using a virtual "injection" of magnetically visible contrast material into the individual arteries. When performed in turn for each artery, the perfusion information may be combined into intuitive 3-colored maps, which show at a glance the ischemic territories perfused by collateral blood supply and, in our patients, correlated well with the collaterals depicted on x-ray angiographic studies. Combined with MR angiography, RPI can potentially provide information comparable to x-ray angiography on the extent and nature (whether by primary channels such as the anterior and posterior communicating arteries or secondary pial arteries) of collateral supply to ischemic brain tissue.

MR-based imaging of cerebral perfusion has many advantages as a noninvasive method of assessing the anatomic and functional status of patients with cerebrovascular disease. RPI does not involve ionizing radiation or exogenous contrast media injection and may be combined with DWI and high-resolution conventional MR imaging. A larger comparative study

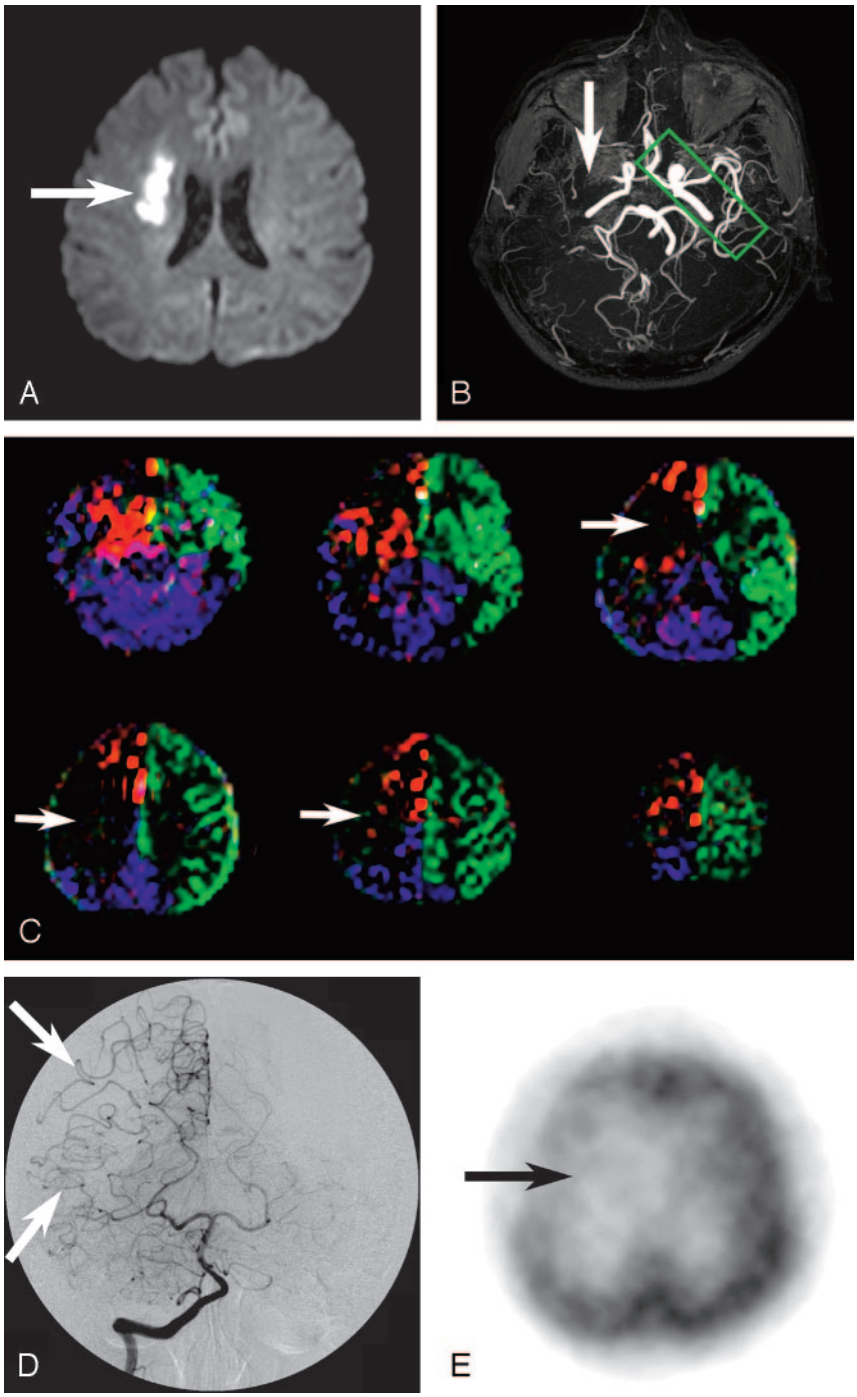

Fig 1. RPI in a 50-year-old man with MCA occlusion.

A, DWI showing acute right corona radiata infarction (*arrow*).

B, MRA shows right MCA occlusion (*arrow*). Selective ASL of the left ICA circulation (*green box*), right ICA, and basilar arterial circulations was performed in turn to produce RPI maps (*C*).

C, Combined RPI map showing the brain tissue perfused by each intracranial artery. The right medial and inferior frontal lobes are supplied by the right ICA (in red), whereas the parietal and inferior temporal lobes are supplied by the basilar artery (in blue). Some areas in the ischemic right MCA territory do not show perfusion by any vascular territory (*arrows*).

D, X-ray angiogram confirms the posterior cerebral artery pial collateral supply to the right parietal lobe (*arrows*).

E, SPECT image after acetazolamide challenge shows an area of reduced vascular reserve (*arrow*) corresponding to the area that does not receive arterial supply from any of the labeled territories (*arrows* in *C*).

would be useful to help define the potential role of RPI in cerebral ischemia. Neuroimaging techniques such as RPI that can correlate the anatomic with the functional status of regional cerebral perfusion would greatly enhance our understanding of the collateral circulation and potentially supplement or replace x-ray angiography for certain clinical indications.[1,13,14]

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