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Clinical usefulness of multiphase arterial spin labeling imaging for evaluating cerebral hemodynamic status in a patient with symptomatic carotid stenosis by comparison with single-photon emission computed tomography: A case study

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ABSTRACT

Multiphase arterial spin labeling (ASL), which obtains the imaged slices with various postlabeling delays, allows for the noninvasive assessment of cerebral hemodynamics that cannot be adequately acquired by single-photon emission computed tomography (SPECT) imaging. We describe the clinical usefulness of multiphase ASL in a patient with symptomatic carotid stenosis by comparison with SPECT at rest using iodoamphetamine. A 75-year-old man was referred to our hospital with severe stenosis of the left internal carotid artery (ICA). While SPECT showed no significant laterality of cerebral blood flow (CBF), multiphase ASL demonstrated relatively delayed perfusion in the left ICA territory. The patient underwent stent placement for the left ICA stenosis. Postoperatively, while SPECT demonstrated no significant laterality of CBF, multiphase ASL revealed improved perfusion in the left ICA territory. This case showed that multiphase ASL could accurately evaluate the cerebral hemodynamic status which could not be detected using pre- and postoperative SPECT.

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Introduction

Magnetic resonance (MR) imaging with pulsed arterial spin labeling (ASL) has been used for noninvasive assessment of cerebral perfusion [1]. More recently, multiphase ASL, in which the imaged slices are acquired with various postlabeling delays (PLD), provides temporal information of cerebral perfusion for patients with chronic cerebral ischemia [2–5]. This technique can offer a noninvasive assessment of cerebral hemodynamics that may not be adequately acquired using single-photon emission computed tomography (SPECT) imaging. This study presents the clinical usefulness of multiphase ASL in comparison with SPECT imaging for evaluation of the hemodynamic status of a patient with symptomatic carotid stenosis.

Case report

A 75-year-old man was referred to our hospital because of a 1-month history of recurring amaurosis fugax in the left eye. He had obesity, hypertension, and mild congestive heart failure. Cerebral angiography revealed approximately 90% stenosis of the left internal carotid artery (ICA) (Fig. 1A). The selective angiographies of the right ICA and vertebral arteries revealed poor collateral flow to the left ICA distribution through the circle of Willis. The brain SPECT (Symbia E, Siemens AG, Berlin, Germany) at rest using N-isopropyl-p-[¹²³I] iodoamphetamine showed no significant decrease of cerebral blood flow (CBF) in the left ICA territory (Fig. 1B). MR imaging with multiphase ASL was performed using a 3T clinical scanner (Achieva, Koninklijke Philips N.V., Amsterdam, The Netherlands). We used a pulsed ASL sequence with flow alternating inversion recovery labeling. The multiphase ASL images were obtained using PLDs of

550, 1050, 1550, and 2050 ms (PLD: start 550 ms, end 2050 ms; increments = 500 ms; field of view: 240 × 240 mm; 64 × 64 matrix; voxel dimensions: 3.0 × 3.0 × 6.0 mm³; repetition time/echo time = 250/16 ms; scan duration: 8 minutes). Those results demonstrated relatively delayed perfusion in the left hemisphere (Fig. 1C).

Because of obesity and congestive heart failure, the patient elected to undergo endovascular angioplasty with stent placement for treatment of the left ICA stenosis. Carotid WALLSTENT (Boston Scientific, Washington, DC) was successfully deployed across a stenotic lesion in the left ICA. The postoperative angiography revealed marked revascularization of the left ICA without any residual stenosis (Fig. 2A). The postoperative brain SPECT at rest using iodoamphetamine demonstrated no significant laterality of CBF (Fig. 2B), as did the preoperative SPECT (Fig. 1B). The postoperative multiphase ASL revealed improved perfusion in the left hemisphere and no difference between hemispheres (Fig. 2C). The postoperative course was uneventful, and the patient was discharged without any neurologic deficit.

Discussion

We report the clinical performance of multiphase ASL to characterize the cerebral hemodynamic status in a patient with symptomatic carotid stenosis, with preoperative prolonged perfusion of the ipsilateral hemisphere. Considering that preoperative SPECT imaging showed no significant laterality, CBF in the ipsilateral hemisphere may have been preserved by leptomeningeal collateral circulation while the ipsilateral ophthalmic flow was impaired. In addition, the postoperative multiphase ASL could detect normalization of the cerebral hemodynamic status in the ipsilateral hemisphere, which could not be identified using pre- and postoperative SPECT imaging.

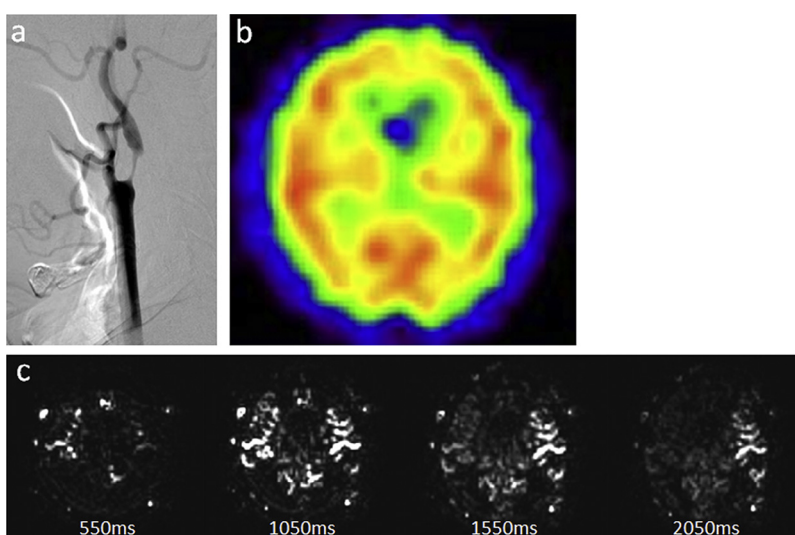


Fig. 1 – Preoperative imaging. (A) Left common carotid angiogram revealed a high-grade stenosis of the left internal carotid artery (ICA) immediately distal to the common carotid artery bifurcation. (B) The brain single-photon emission computed tomography (SPECT) at rest demonstrated no significant laterality of cerebral blood flow (CBF). (C) Multiphase arterial spin labeling (ASL) images with postlabeling delays (PLDs) of 550, 1050, 1550, and 2050 ms demonstrated the relatively delayed perfusion in the left hemisphere.

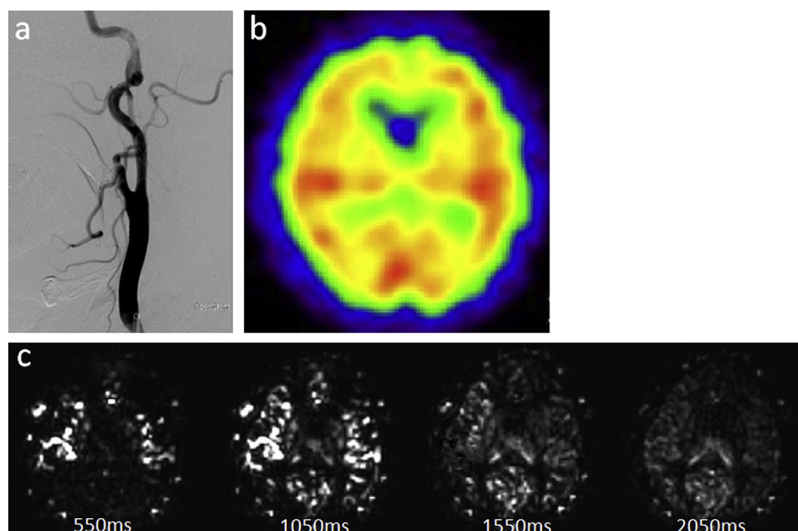


Fig. 2 – Postoperative imaging. (A) Left common carotid angiogram revealed marked revascularization of the left internal carotid artery (ICA) without any residual stenosis. (B) The brain single-photon emission computed tomography (SPECT) at rest demonstrated no significant laterality of cerebral blood flow (CBF). (C) Multiphase arterial spin labeling (ASL) images demonstrated improved perfusion in the left hemisphere and no difference between hemispheres.

ASL MR imaging has been developed to noninvasively assess cerebral perfusion using magnetically labeled blood as an endogenous contrast agent, and its clinical use is increasing [1]. Most ASL techniques to date acquire the image at a single PLD, which can only evaluate the cerebral perfusion status at a single time point. However, for patients suffering from steno-occlusive disease, as in the present case, collateral circulation may cause increased arrival time of the labeled blood to the brain tissue, possibly resulting in underestimation of regional CBF. This limitation can be overcome by using multiphase ASL at various PLDs, which provides the temporal dynamics of cerebral perfusion [2–5]. Preoperative multiphase ASL in the present case allowed accurate evaluation of the cerebral hemodynamic status as delayed perfusion in the ipsilateral hemisphere (Fig. 1C).

Previous studies with positron emission tomography [6] and blood oxygenation level-dependent MR imaging [7] demonstrated significantly reduced CBF in the ipsilateral hemisphere in patients with severe ICA stenosis, which is thought to be caused by decreased flow in the main trunk of the arteries and increased dispersion in the microvasculature. This mechanism may also correspond with our findings of delayed perfusion in the ipsilateral hemisphere, regardless of nonlateralized SPECT results at rest. Further studies that include a larger number of patients are necessary to emphasize the clinical usefulness of multiphase ASL imaging.

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