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CASE REPORT

Transient ischemic attacks – the role of arterial spin labelling

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ABSTRACT

Introduction and aim. Transient ischemic attacks are usually diagnosed by clinical criteria. (1) Arterial spin labelling (ASL) is a noninvasive technique based on magnetic labeling of hydrogen ions in arterial blood with high sensitivity for the detection of oligemic areas in the corresponding cerebral hemisphere to the clinical phenotype. The aim is to demonstrate hypoperfusion using Arterial spin labelling techniques in TIA cases with the objective of intervening with appropriate methods to stop the stroke progression.

Description of the cases. The authors analyzed 90 cases of TIA in order to ultimately select four cases of clinical TIA with Arterial spin labelling to test the proof of concept.

Case 1. 47-year-old male with transient right-sided limb weakness and corresponding ASL hypoperfusion.

Case 2. 57-year-old male with recurrent transient ischemic symptoms and ASL showing hypoperfusion in the right parietal lobe.

Case 3. 73-year-old male with a high risk TIA and right parietal hypoperfusion on ASL that evolved into an infarct.

Case 4. 30-year-old female with a sensory TIA and hypoperfusion in the right cerebral hemisphere on ASL.

The hypothesis is that Arterial spin labelling will be able to demonstrate a penumbra in brain tissue in TIA cases which suggests likely progression to stroke and help in appropriate intervention to stop progression in real time. The following sequences were used during the brain MRI: diffusion-weighted imaging, fluid attenuated inversion recovery, apparent diffusion coefficient, and ASL sequences after written informed consent. Philips Ingenia 3Tesla machine obtains a 3D pseudocontinuous ASL sequence with a color coded map is obtained by Philips Ingenia 3 Tesla machine with a magnet weight of 4600 kg, 90-degree flip angle, and total duration of 3 minutes and 19 seconds.

The authors present a series of 4 cases in which patients had clinical TIA and had hypoperfusion on ASL sequence corresponding to the clinical manifestation depicting the penumbra. ASL hypoperfusion was assessed visually and cerebral blood flow (CBF) data was averaged to develop a visual CBF map.

Conclusion. Arterial spin labelling is a novel marker for hypoperfusion that indicates brain parenchyma under threat due to either stenosis in vessels of the cerebral circulation or embolic phenomenon.

Keywords. arterial spin labeling, magnetic resonance imaging, stroke, transient ischemic attack

Introduction

Transient ischemic attacks are usually diagnosed by clinical criteria.[1] Arterial spin labelling (ASL) is a non-invasive technique based on magnetic labelling of hydrogen ions in arterial blood with a high sensitivity for the detection of oligemic and hypoperfused areas in the corresponding cerebral hemisphere to the clinical phenotype. ASL pulse sequences fall into three main kinds that are frequently found in clinical Magnetic resonance imaging (MRI) scanners: pulsed ASL (PASL), pseudo-continuous ASL

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(pCASL), and continuous ASL (CASL). In frequent clinical applications, 3T pCASL is recommended as the preferred ASL technique by the ASL consensus ISMRM 2014 guideline.[2] Furthermore, ASL approaches are being developed and include vessel-encoded pCASL (ve-pCASL), acceleration-selective (AccASL), velocity-selective ASL (VS-ASL) and time-encoded ASL (te-ASL).[3]

Aim

The authors present 4 cases of clinical TIA in which neuroimaging showed hypoperfused areas in the ASL sequence. The aim is to demonstrate hypoperfusion using ASL techniques in TIA cases with the objective of intervening with appropriate methods to stop the stroke progression.

Description of the cases

The authors have evaluated four cases of TIA with ASL in a total of 90 cases of TIA to test the proof of concept. The hypothesis is that ASL will be able to demonstrate a penumbra in brain tissue in TIA cases which suggests likely progression to stroke and help in appropriate intervention to stop progression in real time. The following sequences were used during the Brain Magnetic Resonance Imaging: Diffusion weighted imaging (DWI), Fluid attenuated inversion recovery (FLAIR) sequence, apparent diffusion coefficient imaging and ASL sequences after written informed consent. A 3D pseudocontinuous ASL sequence with color coded map was done using the Philips Ingenia 3Tesla machine with a magnet weight of 4600kg, 90-degree flip angle and total duration of 3 minutes and 19 seconds. Clinical TIA syndromes older than 18 years were included, and we excluded cases of ischemic and hemorrhagic stroke, stroke mimics, and secondary and venous strokes.

Case 1.

A 47-year-old male, known hypertensive in treatment, presented acute onset right upper limb and lower limb, associated with slurring of speech slurred and difficulty in comprehension that resolved in 10 minutes spontaneously. In the emergency room, he suddenly developed similar weakness and slurring of speech. One week before presentation, he had a sudden onset of confusion and weakness in the right upper limb while driving which resolved in minutes. At presentation, his heart rate was 54 beats per minute, blood pressure 180/100 mm Hg. He had an ABCD2 score of 4 with weakness and dysarthria of the right upper and lower extremities, facial weakness, and mild aphasia which resolved completely resolved 10 minutes later. The investigations were normal except for electrocardiography which showed inversions of the T wave in the inferior and lateral leads with sinus bradycardia. Troponin I level was less than 0.01 and echocardiography was normal. The brain showed no acute infarct, but ASL showed hypoperfusion of the left MCA territory (middle cerebral artery), which was consistent with the patient's symptoms. Magnetic resonance angiography revealed no intracranial or extracranial stenosis and the repeat ASL showed a reversal of hypoperfusion 24 hours later (Fig. 1).

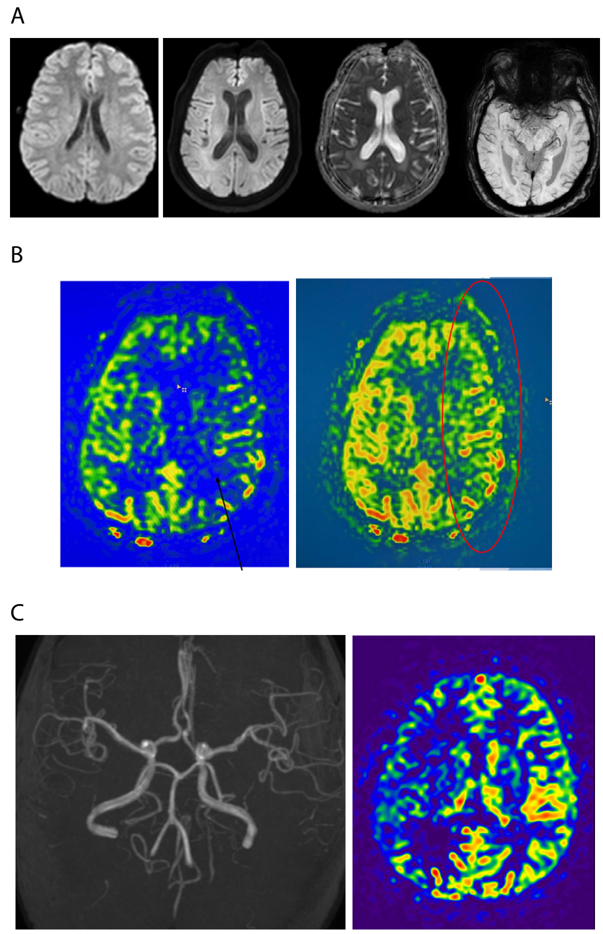


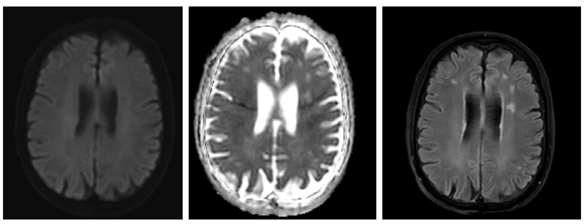
Fig. 1. A: Case 1- A 47-year-old male who presented weakness and language abnormality, his MRI, FLAIR, ADC image and Susceptibility weighted imaging showing no acute infarct, B: ASL sequence depicting hypoperfusion in the left MCA territory (black arrow and red circle), C: MR angiogram of brain that was normal and ASL sequence after 24 hours revealed normal perfusion

Case 2.

A 57-year-old male, a known case of hypertension presented with acute onset weakness and a tingling sensation of left upper limb and the lower limb with heaviness of the tongue which resolved spontaneously in 10 minutes. On presentation, his blood pressure was 140/80 mm Hg. Initially he had left upper and lower limb drift, dysarthria, and facial weakness which resolved to only dysarthria 10 minutes later and he then had complete resolution of symptoms after 15 minutes, making his ABCD2 score 4. Blood investigations were normal. Echocardiography showed mild concentric left ventricular hypertrophy.

Magnetic resonance imaging of the brain revealed no acute infarction, but ASL showed hypoperfusion in the right parietal lobe. CT angiography revealed right Internal Carotid artery stenosis. Repeat ASL done 24 hours later was normal (Fig. 2).

A



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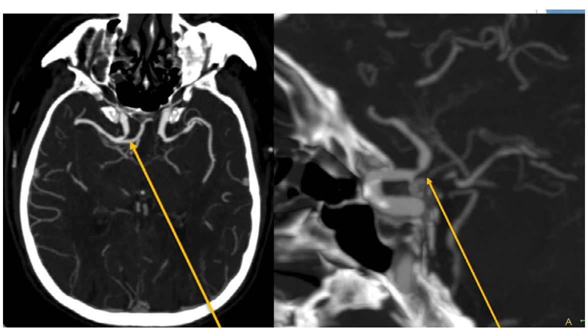

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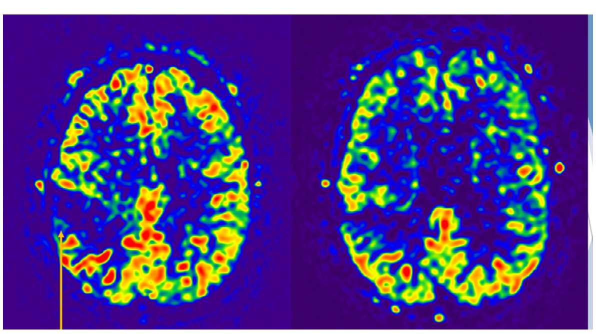

Fig. 2. A: Case 2: A 57-year-old hypertensive male with acute left-sided paraesthesisas and weakness of the extremities, his brain MRI diffusion, ADC image and FLAIR showing no acute infarction, B: axial and sagittal CT images depicting Right ICA intracranial part (yellow arrow), C: ASL sequence initially showing hypoperfusion (yellow arrow) and followed by normal perfusion

Case 3.

A 73-year-old male, a known case of diabetes and hypertension with ischemic heart disease and coronary angiogram suggestive of critical triple vessel disease, underwent coronary artery bypass surgery. On postoperative day 2 he developed acute onset weakness of the left upper and lower extremities, deviation of angle of mouth to the right side, and speech loss. The symptoms lasted for 40 minutes, and then there was complete recovery. On examination, his blood pressure was 190/90 mm Hg. Initially had weakness and dysarthria in the left upper and lower extremities, plantar response to the left extensor, facial weakness, inattention, and confusion which resolved 40 minutes later, making his ABCD2 score 7. Magnetic resonance imaging of the brain did not show acute infarct, but ASL revealed hypoperfusion in the right MCA territory. Repeat MRI of the brain 24 hours later showed an infarct of the MCA territory in the right parietal region with luxury perfusion in the ASL sequence (Fig. 3).

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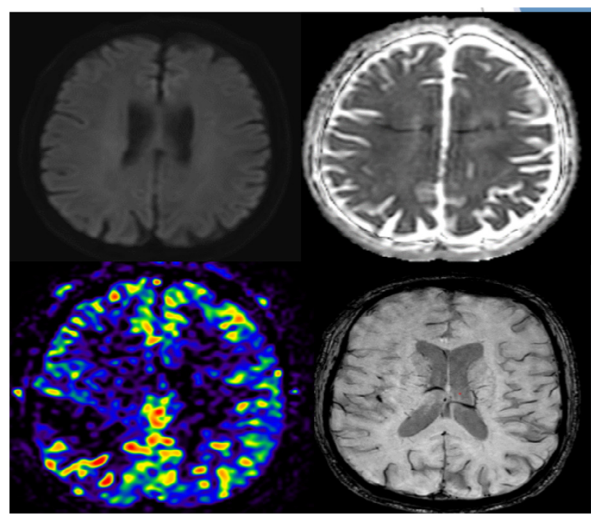

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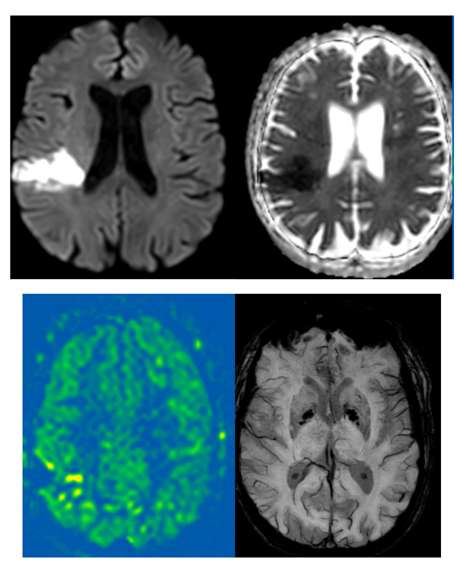
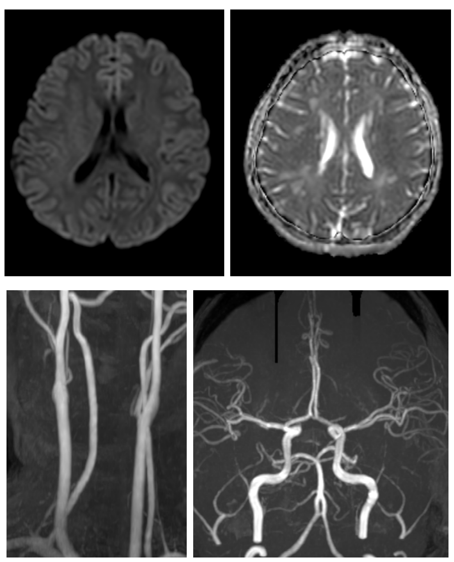


Fig. 3. A: Case 3: A 73-year-old male after coronary artery bypass surgery developed acute left sided weakness, his brain diffusion and ADC showing no acute infarct and ASL suggestive of hypoperfusion in the right parietal region with a small clot visualized on susceptibility-weighted imaging in the right parietal region, B: MRI of the brain 24 hours later: diffusion-weighted imaging and ADC showing infarct of the right MCA territory in the right parietal region, ASL shows luxury perfusion in the corresponding area, no clot is seen on susceptibility-weighted imaging

Carotid Doppler revealed atherosclerotic plaques in bilateral common carotid arteries and right internal carotid artery without any significant luminal compromise. Electrocardiography had pathological Q waves in the inferior and anterior leads. Echocardiography showed basal mid distal lateral wall apex basal mid posterior wall, basal septum akinetic, moderate left ventricular systolic dysfunction, and an ejection fraction of 30%.

A



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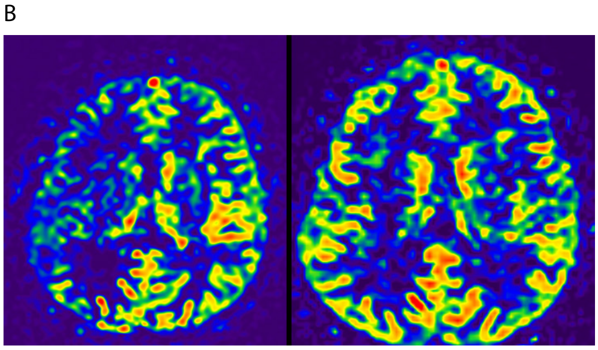

Fig. 4. A: A 30-year-old woman after emergency caesarean section for preeclampsia developed left sided paraesthesias, her brain with angiography with no acute infarct nor vessel stenosis, B: ASL showing hypoperfusion in the right cerebral hemisphere at presentation and normal perfusion 24 hours later

Case 4.

A 30-year-old antenatal mother underwent an emergency lower segment caesarean section due to preeclampsia. On the second postoperative day, she developed sudden onset paresthesia of the left upper and lower extremities associated with acute severe bifrontal headache. The symptoms lasted for the next 40 minutes and then there was complete recovery making her ABCD2 score 2. MRI of the brain with angiography had no acute infarct nor evidence of any vessel stenosis but ASL sequence showed hypoperfusion in the right MCA territory. Repeating ASL 24 hours later was normal (Fig. 4). Echocardiography did not reveal left ventricular dysfunction. The possibility of TIA and postpartum reversible cerebral vasoconstriction syndrome was investigated and treated, and rest of the postpartum period was uneventful.

Discussion

In our study, we had four cases where the ASL sequence revealed evidence of a penumbra tissue in high-risk TIA. Two of these cases had arterial occlusion that was later diagnosed on vascular imaging. In another study of 116 cases, Zaharchuk et al. found that the sensitivity and specificity of arterial spin labeling in the diagnosis of perfusion abnormalities in TIA was 55.8% and 90.7%, respectively.[4] ASL perfusion increased the detection of ischemia in patients with TIA and was most useful in conjunction with DWI.[5]

Comparing pCASL, CASL, and dynamic susceptibility contrast (DSC) MRI in ICA Stenosis highlights the plausibility of ASL-based measurements and provides additional insights by mapping perfusion territory shifts.[6,7]

In acute ischemic stroke, the concept of determining the salvageable penumbra and imaging the mismatch region is most important. DSC imaging was used to categorize patients into clinically significant categories (ie, those with a mismatch, without a mismatch, or with reperfusion). Compared to that ASL is a suitable method for image tissue perfusion and collaterals owing to its noninvasive nature and sensitivity to delayed arterial arrival. Research indicates that ASL can predict the regional distribution of collaterals, demonstrating strong concordance in individuals with arterial steno-occlusive disease.[8,9]

ASL also has clinical applications in various other fields of medicine. In Alzheimer's disease, ASL has shown a reduction in CBF in a posterior parietal distribution, including the precuneus, posterior cingulate, angular gyrus, and superior parietal gyrus.[10-12] Taylor et al. found posterior hypoperfusion in the posterior cingulate and areas of visual association areas in Lewy body dementia.[13]

ASL can also help in locating a potential epileptogenic focus in epilepsy patients. During the acute peri-ictal period, CBF is typically increased due to pathologic neuronal activity, while in the chronic interictal period, CBF is typically reduced as the epileptogenic region is less functional compared to normal brain tissue.[14-18]

Posterior reversible encephalopathy syndrome can show higher CBF in the afflicted areas of ASL, lending support to the hypertension-hyperperfusion idea. However, it can indicate lower CBF as well, which promotes the vasoconstriction-hypoperfusion concept.[19,20]

ASL can also help with the follow-up of arteriovenous malformations by exposing the location of the nidus, allowing for longer follow-up and more objective monitoring of nidus obliteration after radiosurgery or partial embolization.[21] Compared to CT perfusion (CTP) studies, the range of ischemic penumbra determined by ASL-CBF and DWI mismatch was consistent with CTP.[22]

The limitation of our study is that our sample size was very small as this was done to test proof of concept. This novel concept warrants further research in larger samples to establish the efficacy of ASL in identifying penumbra tissue in the brain.

Conclusion

ASL is a surrogate marker for hypoperfusion that indicates brain parenchyma under threat due to stenosis in vessels of cerebral circulation or embolic phenomenon. ASL is a useful imaging technique for diagnosing high-risk TIA and minor stroke.

Declarations

Funding

Not applicable.

Author contributions

Conceptualization, S.P.G.; Methodology, S.P.G., D.G., V.M. and S.D.; Validation, S.P.G., D.G. and V.M.; Formal Analysis, S.D.; Investigation, V.M. and S.D.; Resources, S.D.; Data Curation, S.D.; Writing – Original Draft Preparation, S.D.; Writing – Review & Editing, V.M. and D.G.; Visualization, V.M.; Supervision, S.P.G.; Project Administration, S.P.G.

Conflicts of interest

There are no conflicts of interest.

Data availability

The data used and/or analyzed during the current study are open from the corresponding author on reasonable request.

Ethics approval

The authors reported that they acquired the necessary informed consent form from the patients, who consented to the publication of their photo and other clinical information. Patients were informed that confidentiality would be ensured.

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