Acceleration-Selective Arterial Spin Labeling (AccASL) for Intracranial MR Angiography

Makoto Obara[1], Osamu Togao[2], Masami Yoneyama[1], Tomoyuki Okuaki[3], Shuhei Shibukawa[4], and Marc Van Cauteren[3]
[1]*Philips Electronics Japan, Minato-ku, Tokyo, Japan,* [2]*Department of Clinical Radiology, Graduate School of Medical Science, Kyushu University, Fukuoka, Japan,* [3]*Philips Healthcare, Tokyo, Japan,* [4]*Department of Radiology, Tokai University Hospital, Kanagawa, Japan*

TARGET AUDIENCE Researchers and clinicians interested in neurovascular imaging

INTRODUCTION Recently, motion-sensitized gradients (MSG) based arterial spin labeling (ASL) is used for non-contrast enhanced MR perfusion imaging or MR angiography (MRA)[1-4]. As MSG modifies signal from flowing spins by dephasing their magnetization, it can be used for labeling of flowing spins. Regarding intracranial MRA, one important clinical demand is selective visualization of arteries. This is challenging in MSG based approach as venous spins are also labeled. Especially, the signals in cortical veins needs to be suppressed as it is difficult to distinguish them from arterial blood signals. Recently a gradient design for arterial selective labeling has been proposed by setting the effective gradient first moment (m_1) to zero [3,4]. This will make MSG sensitive to acceleration, while spins flowing with constant velocity will be rephrased. This approach is called acceleration-selective ASL (AccASL). As the pulsatile arterial flow has a major acceleration component, while venous flow is mostly constant, only arterial blood spins will be labeled. In this work we implemented AccASL for intracranial MRA and validated the AccASL technique by comparing the AccASL peripheral artery visualization with the conventional time-of-flight (TOF) approach.

METHODS AccASL scheme: The AccASL sequence consists of control (T2-preparation without MSG) and label (with MSG) parts followed by T1-weighted turbo field echo (T1-TFE) as shown in Fig 1. The T2-preparation consist of a 90° excitation pulse, two 180° MLEV refocusing pulses [5], and a 90° flip back pulse. The MSG in the labeling part are designed with all gradients having the same sign to achieve a zero m_1. The MSG strength is numerically represented by the acceleration that causes a phase change of π (AENC: acceleration-encoding), analogous to VENC [4].

Subject and equipment: The AccASL technique was implemented on a 3.0T scanner (Philips Achieva R3). Five healthy subjects were examined after obtaining informed consent as required by institutional review board. Two kinds of images, AccASL and TOF, were acquired for comparison.

AccASL and TOF sequence parameters: The AccASL acquisition parameters were: sequence T1-TFE; TR/TE 7.5/3.5ms; FA 11°; ETL 60; SPIR fat suppression; 3D slab thickness 120mm; voxel size 0.39*077*1.0 (120 partitions); SENSE factor 2.0, AENC 2.38m/s^2; acquisition time for label and control pair 7m29s. The TOF acquisition parameters were: sequence T1weighted Fast Field Echo; TR/TE 20/3.5ms; FA 20°; 3D slab thickness 120mm with 4 chunks; voxel size 0.39*0.77*1.0 (120 partitions); SENSE factor 2.0, acquisition time 7m21s. Geometry-related parameters in TOF were same as those used in AccASL.

Assessment of vessel visualization ability: For the vessel visualization assessment, an axial maximum intensity projection (MIP) with 50mm slab thickness was generated centered on top of M2 artery. Then a straight line was drawn in the middle cerebral artery (MCA) area and the signal profile along that line on both AccASL and TOF images was obtained. Average signal intensity and standard deviation in white matter tissue (SI_{ave} and SD) were also measured by drawing region of interest (ROI) on 50mm slab MIP image. Signal was defined as coming from a vessel if:

$$\text{Signal} > SI_{ave} + 3*SD.$$

We used the number of vessel signal peaks in the line profiles for AccASL (#AccASL) and TOF (#TOF) respectively as marker for visualization. In addition, the appearance of cortical vein signal was checked by a radiologist with fourteen years of experience in neuroradiology (OT) and an MR scientist with twelve years of experience (MO).

RESULTS Representative coronal MIPs with full slab and transverse MIPs with 50mm slab thickness generated from AccASL and TOF are shown in Fig. 2. In addition, representative line profiles are shown in Fig. 3. for AccASL and TOF. Compared to TOF, AccASL images show more peripheral vessels in MCA area. The number of vessels counted in line profile #AccASL is higher than #TOF in all five volunteers, as shown in Fig.4. There was no signal from cortical veins in AccASL images from all five volunteers.

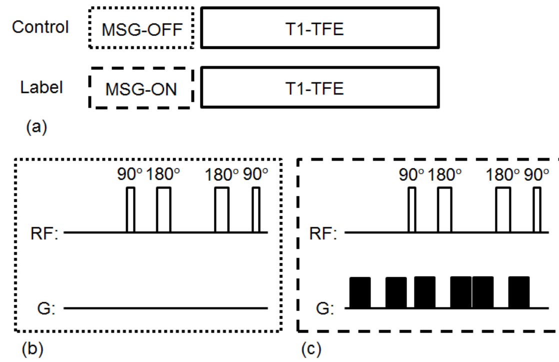
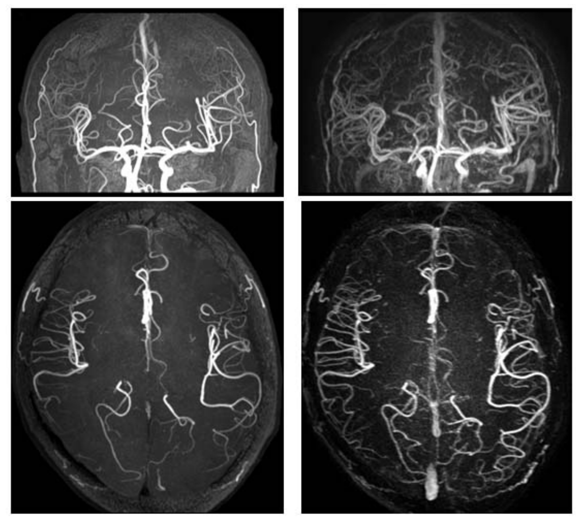
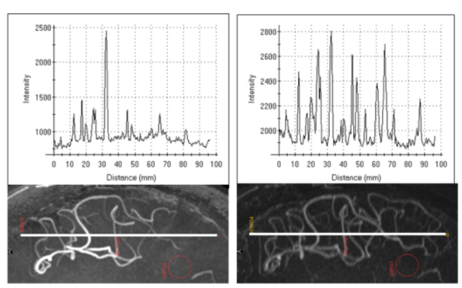


Fig. 1. : (a)AccASL scheme, (b)Control, (c)Label



TOF AccASL

Fig. 2. : TOF(left) and AccASL(right) images
Coronal full size MIP (upper row) and axial 50mm slab MIP are shown.



TOF AccASL

Fig. 3. : TOF(left) and AccASL(right) signal line profile in MCA area.

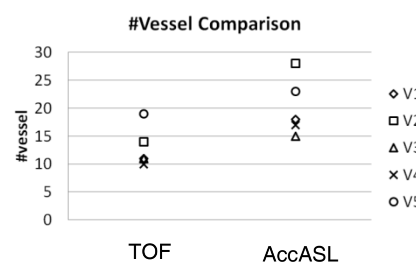


Fig. 4. : Number of visualized vessels in line profile comparison

CONCLUSION We have demonstrated 3D intracranial MRA using AccASL technique. The results indicate that AccASL can visualize peripheral arterial both selectively and with better efficiency compared to the TOF approach.

REFERENCE 1. Wong EC et al, MRM 2006;55:1334, 2. Kimura T et al, MRM 2009;62:450, 3. Schmid S et al, MRM 2014;71:191, 4. Priest AN et al, MRM 2014;72:699, 5. Levitt M et al, JMR 1982;47:328