Non contrast enhanced 3D volumetric time-resolved MRA combining multiple phase pCASL(CINEMA-pCASL)

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INTRODUCTION

Non-contrast-enhanced MR angiography (MRA) using arterial spin labeling (ASL) technologies has remarkably widened the clinical application of the modality [1.2]. Hemodynamic information can be acquired on different time axes by changing the delay time preceding signal collection [3]. However, repeated imaging with differing delay times extends imaging time substantially and impedes clinical use. Recently, a new technique was presented for non-contrast 3D volumetric time-resolved MRA (Contrast inherent INflow Enhanced Multi phase Angiography; CINEMA) [4]. With this technique, multiple phases with different delay time can be acquired followed by only a spin-labeling pulse, enabling significant shortening of the scan time. In this study, we propose a combination of CINEMA technique with pseudo-continuous arterial spin labeling (CINEMA-pCASL). CINEMA-pCASL is expected as a technique that enables diachronic observation of hemodynamic as in MR-DSA and extensive 3D volume acquisition with the whole brain as a target. We present a preliminary study of CINEMA-pCASL sequence and discuss its clinical relevance.

METHODS

Theory and Pulse Sequence: CINEMA-pCASL technique combines pCASL [5] with 3D segmented T1 weighted gradient echo sequence (3D-T1-TFE). pCASL preparation scheme with the Look-Locker sampling was used for spin labeling in this study (Fig 1)[6,7]. Seven phases of labeling and control images were acquired in an interleaved mode. Upon completion of two acquisitions, corresponding temporal phases with identical inversion delay were subtracted. MIPs were then created for each subtracted data set in three orthogonal directions.
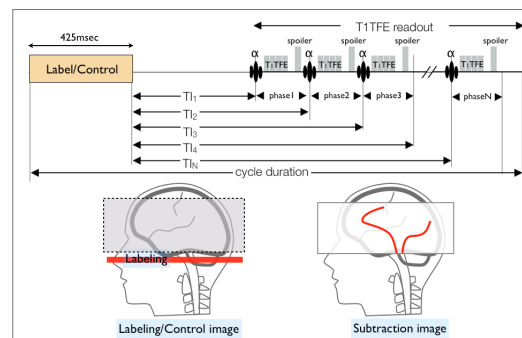
Volunteer examination: Local - IRB, consisted of 8 healthy volunteers, approved the study. All examinations were performed on a Philips Achieva 3.0 Tesla scanner with software release 3.2 and equipped with an 8-element head coil. CINEMA-pCASL was implemented with the following parameters: FOV=220×200mm2, Matrix=224×162, 3D acquisition with 100×1mm slices, resolution =1×1×1mm3, flip angle=12°, TR=8.5ms, TE=4.2ms, SENSE factor=3.0, TI/ΔTI/final TI=300ms/300ms/2.0s, number of acquired time points=6. Labeling was performed by applying 425ms labeling duration, 200 to 2000 pulses with increments of 250ms produces 450, 700, 950, 1200, 1450, 1700 ms. A transverse labeling plane was positioned 9 cm below the imaging center. Total acquisition time is approximately 5 min. 3D TOF MRA was performed for anatomical comparison on all subjects with the following sequence parameters: FOV=220×200mm2, Matrix=224×162, 3D acquisition with 100×1mm slices, resolution =1×1×1mm3, flip angle=12°, TR=24ms, TE=1.2ms, SENSE factor=2.0.

Fig 1. Schematic of the sequence for CINEMA-pCASL. CINEMA-pCASL technique combines multiple phases pCASL with 3D T1TFE sequence. Labeling geometry show imaging and background suppression slab (dashed line box), Labeling plane is indicated as red line.
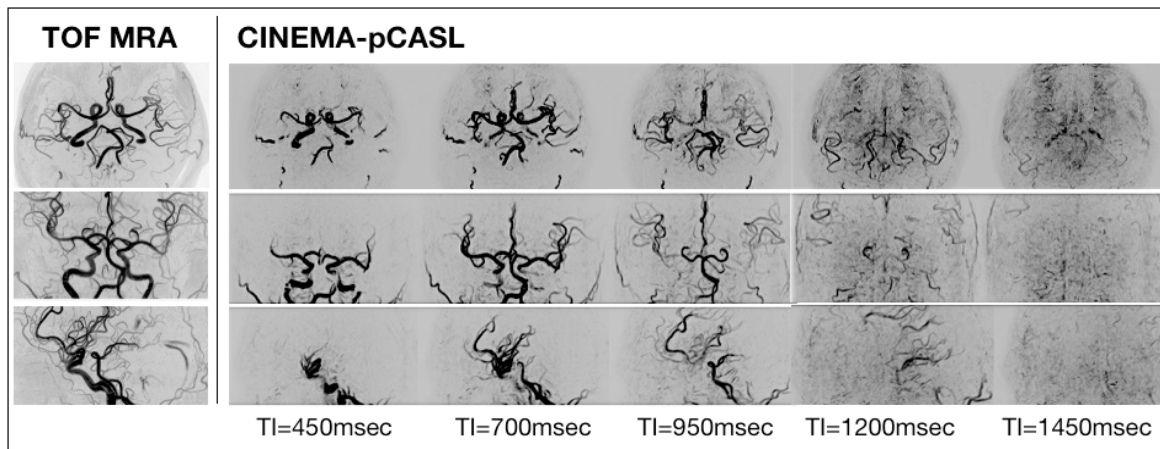
RESULTS

CINEMA-pCASL could extract the blood flow in the whole brain at an interval of about 300 ms with a high degree of vessel specificity and showed good agreement compared to TOF-MRA (Fig 2). Static tissues are effectively removed in subtracted images for all temporal phases. Blood - background tissue contrast is consistently achieved over the entire TI (100 ms to 1500 ms). The limitation of CINEMA-pCASL is that the continuous data collection after a single labeling pulse causes relaxation of longitudinal magnetization, results in signal decrease of flowing blood into the slice. However, this was shown not to affect the interpretation of the images in our studies where spins are constantly labeled.

CONCUSION

This preliminary study demonstrated the usefulness of CINEMA-pCASL technique in evaluating the cerebral vasculature. High quality both in temporal and spatial resolutions was simultaneously achieved, obviating the need for contrast agent. Patients carrying cerebrovascular abnormalities such as AVM and Moyamoya disease are subjects of further investigations.

Fig 2. CINEMA-pCASL and TOF images acquired from a healthy volunteer.
MIP images acquired at representative phases form one subject with a 250ms temporal resolution and 1×1×1mm3 spatial resolution.

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