Vessel-selective non-contrast enhanced time-resolved MR angiography using PULSER prepared 4D T1TFE in intracranial arteries

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INTRODUCTION

Non-contrast MRA using ASL technologies has remarkably widened the clinical application of this modality [1.2]. Hemodynamic information can be acquired by repeated scanning with changing the delay time preceding signal collection. However, it further extends scan time and therefore 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-FAIR) [3] . With this technique, multiple phases with different delay time can be acquired followed by only a single FAIR-type spin-labeling, enabling signicant shortening of the scan time. However, it only allows to visualize all brain vessels together, and cannot select specific vessels like the internal carotid arteries (ICAs), the basilar artery (BA), or the colllateral circulation.

We have proposed a vessel-selective 3D volumetric non-contrast time-resolved MRA technique termed vsCINEMA. vsCINEMA consists of the vessel-selective PULSER [4.5] preparation module for vessel selection and a 4D-T1-TFE readout. We hypothesize that vsCINEMA allows selective labeling of single intracranial arteries consisting of high resolution 4D data with wide coverage of the brain.

MATERIALS AND METHODS

Pulse sequence: The vsCINEMA technique combines PULSER with a 3D T1 TFE. The PULSER preparation scheme, with Look- Locker sampling [6] used for spin tagging. The labeling region was set at 20 mm superior to the imaged slice with a 100 mm range. In each cycle, the imaged slice was saturated by a series of four RF pulses to eliminate signals from static tissues. 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. Angiography images were obtained by complex subtraction of label and control images and combined into a color-encoded frame. MIPs were then created for each subtracted data set in three orthogonal directions.

Volunteer and patient examination: IRB approval was obtained and all study participants provided written informed consent. A total of 8 healthy volunteers and 4 patients were included. All examinations were performed on a Philips Achieva 3.0 Tesla scanner with software release 2.6 and equipped with an 8-element head coil. In the volunteer study, selective labeling of major cerebral arteries (ICA, BA) was achieved and qualitatively compared to the clinical TOF sequence and MR-DSA. The signal strength of stationary tissues (gray and white matter) and internal carotid (ICA), anterior (ACA), middle (MCA), and posterior cerebral arteries (PCA) were measured on the images. In the patient study, 4 subjects underwent vessel selective ASL angiography. Subsequently, the results were compared to TOF MRA. vsCINEMA was implemented with the following parameters: FOV=220×200mm2, Matrix=224×162, 3D acquisition with 100×1mm slices, resolution =1×1×1mm3, flip angle=10°, TR=4.5ms, TE=2.2ms, SENSE factor=3.0, TI/ΔTI/final TI=80ms/200ms/2.0s, number of acquired time points = 8. The scan time was approximately 7min.

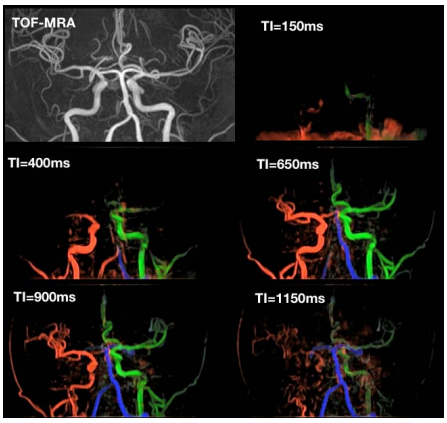

Fig 1. Selected frames in vsCINEMA sequence after separating the vascular components, inflow subtraction and coronal MIP. Colors are used to represent the origin of the blood signal (red = RICA, green = LICA, blue = BA).

RESULTS AND DISCUSSION

vsCINEMA could extract the blood flow in the whole brain at an interval of about 200 ms with a high degree of vessel specificity and showed good agreement compared to TOF-MRA and MR-DSA (Fig 1.2). Figure 3 shows the signal intensity of vsCINEMA images from the volunteer studies. 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 2000 ms). The limitation of vsCINEMA is that the continuous data collection after a single IR pulse causes relaxation of longitudinal magnetization, resulting in signal decrease of flowing blood into the slice. Therefore, TI times of 1200-1500 ms or less must be used to avoid excessive saturation effect and for better observation of slow blood flow in the periphery.

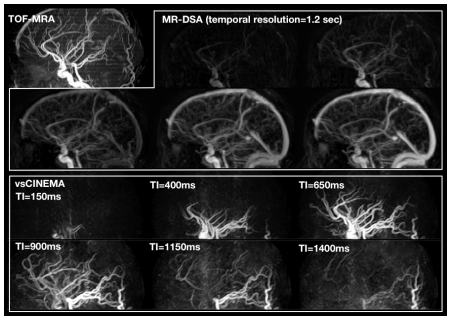

Fig 2. MIPs of selectively labeled feeding vessels in a healthy volunteer compared to corresponding MR- DSA images and TOF-MRA showed good agreement compared to TOF-MRA and MR-DSA.

CONCLUSION

vsCINEMA allows visualizing the dynamics of cerebral blood flow with high spatial and temporal resolutions. Patients carrying cerebrovascular pathologies such as AVM and moyamoya disease are good candidates for further investigations (Fig 4).

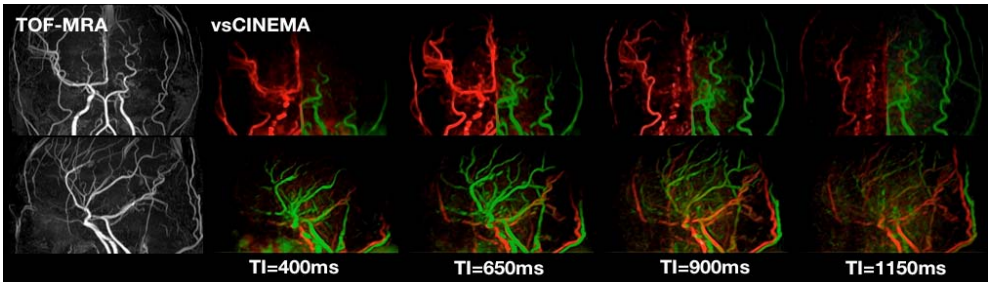

Fig 4. vsCINEMA and TOF images in Moyamoya disease. Color is used to represent the origin of the blood signal (red = RICA, green = LICA,

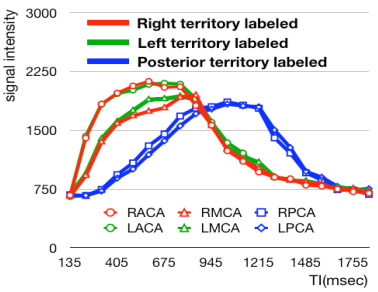

Fig 3. Signal intensity curves of different arterial segments from volunteer studies.

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