Non Contrast Time-Resolved MRA combining High Resolution Multiple Phase EPISTAR (CINEMA-STAR)

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Introduction

Detailed information on anatomy and hemodynamics in cerebrovascular disorders such as AVM and Moyamoya disease is mandatory for defined diagnosis and treatment planning [1]. DSA may still be a gold standard for diagnostic modality but is otherwise invasive. Contrast-enhanced dynamic MR angiography (CE-dMRA) is a useful technique but poses a risk associated with contrast agent [2]. Currently most widely used non-contrast MRA techniques are TOF and PC. Also arterial spin labeling (ASL) technique has come to be applied to MRA and perfusion imaging in recent years [3, 4]. Those non-contrast techniques are, however, mostly limited to a single frame images. Recently we have proposed non-contrast time-resolved MRA technique termed Contrast inherent inflow enhanced multi phase angiography combining spatial resolution Echo planar imaging based signal targeting and alternating radiofrequency (CINEMA-STAR). CINEMA-STAR drastically improves temporal axis resolution from the order of a second as in CE-dMRA to tens of milliseconds (50ms) in this study, without compromising spatial resolution. We present a preliminary study of CINEMA sequence and discuss its clinical relevance.

Methods

As shown in Figure 1, CINEMA-STAR technique combines multiple phases STAR [5] with 2D segmented gradient echo EPI sequence. The labeling region was located 20mm superior to the imaged slice with a 100mm thickness. In each cycle, the imaged slice was saturated by a series of four RF pulses to eliminate signals from static tissues first. After labeling, the imaged slice was post-saturated again by a single RF pulse. Nineteen phases of labeling and control images were acquired in an interleave mode. Upon completion of two acquisitions, corresponding temporal phases of two acquisitions with identical inversion delay are subtracted. The signal was then continuously acquired by a multiple phase with 2D gradient echo EPI readout. CINEMA-STAR was implemented with the following parameters: FOV=220×200mm2, Matrix=256×192, slice thickness=5mm, flip angle=30°, TR=2000ms, TE=10ms, SENSE factor=3.0, TI/ΔTI/final TI=100ms/70ms/2.0s, number of acquired time points = 19. The scan time was approximately 4min. A set of 20 ASL acquisitions was made for signal averaging. The study was approved by local-IRB, consisted of 10 healthy volunteers and 2 patients. All experiments were performed on a Philips Achieva 3.0 Tesla scanner with Nova Dual gradients and software release 2.6 was used together with an 8 elements head coil. The alteration in longitudinal magnetization of stationary tissues and moving tissues (blood stream in this study) was converted into numbers by simulation. The signal strength of stationary tissues and blood stream were measured from images obtained from volunteer subjects. The image quality of CINEMA-STAR was compared with that of TOF MRA in terms of the depiction of the detailed anatomy.

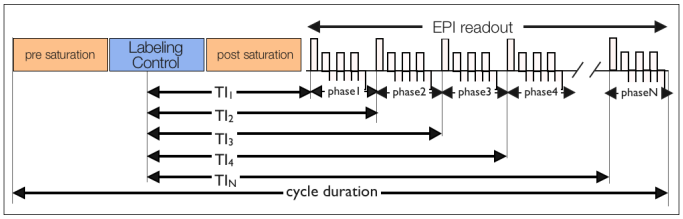

Fig 1. Schematic of the sequence for CINEMA-STAR. CINEMA-STAR technique combines multiple phases STAR with 2D segmented gradient echo EPI sequence.

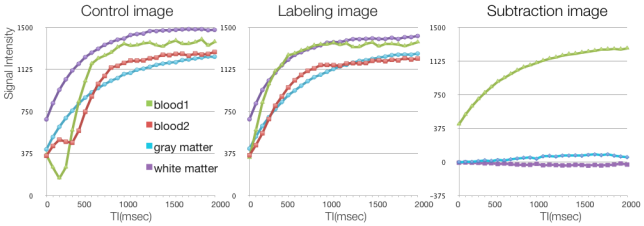

Fig 2. Signal intensity curves in the control image, labeling image, and subtracted images.

Results

Major intracranial blood vessels were extracted successfully in all volunteer studies. Despite recovery of longitudinal magnetization and change of signal intensity over time after magnetization preparation, static tissues are effectively removed in subtracted images for all temporal phases, as expected (Fig 2). CINEMA-STAR can extract the blood flow in the major intracranial arteries at an interval of 50 ms and thus permitted us to observe vascular construction in full by preparing MIP images of axial acquisitions with 1.6 × 1.6 mm^2 spatial resolution. In MIP images TOF and CINEMA-STAR sequence, the quality of appearing the main blood vessels and their branches was identical, while CINEMA-STAR sequence provided additional hemodynamic information (Fig 3). Figure 4 shows in a control subject representative non-contrast time resolved MRA to RPI [6, 7] labeling of the left and right ICAs and posterior circulation (basilar artery and vertebral arteries). Although the spatial resolution of CINEMA-STAR is lower than TOF, the high temporal resolution (50ms) provides complementary information of static TOF MRA.

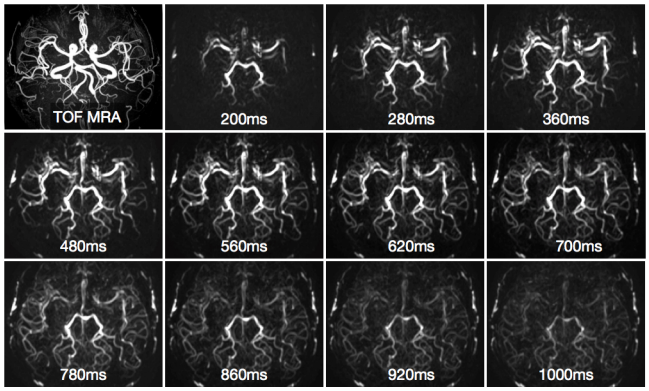

Fig 3. CINEMA-STAR and TOF MRA images. CIENAM-STAR(MIP) images acquired at representative phases form one subject using CINEMA-STAR with a 80ms temporal resolution and 1.6 × 1.6 mm^2 spatial resolution.

Conclusion

This preliminary study demonstrated the usefulness of CINEMA-STAR technique in evaluating the cerebral vasculartre. 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.

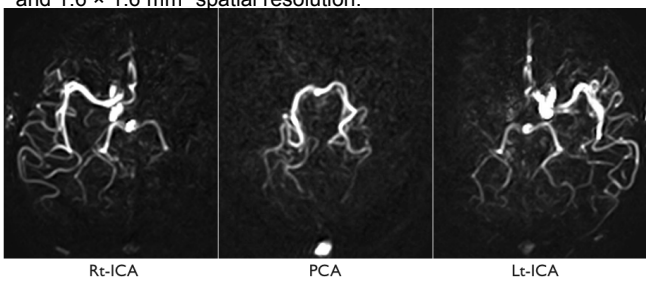

Fig 4. RPI labeling of the left and right ICAs and posterior circulation (basilar artery and vertebral arteries).

References

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