High frame rate CINEMA: an improvement of temporal resolution in non-contrast-enhanced time-resolved MR angiography

Masanobu Nakamura[1], Masami Yoneyama[1], Takashi Tabuchi[1], Atsushi Takahara[2], Makoto Obara[2], Taro Takahara[3], and Satoshi Tatsuno[1]
[1]Yaesu clinic, Tokyo, Japan, Japan, [2]Philips Electronics Japan, Tokyo, Japan, [3]Tokai University School of Engineering, Kanagawa, Japan

INTRODUCTION

Hemodynamic information is required for the accurate diagnosis, effective treatment, and follow-up examination of numerous cerebrovascular diseases [1,2]. Recently, a new technique was presented for non-contrast volumetric time-resolved MRA (Contrast inherent INflow Enhanced Multi phase Angiography; CINEMA) [3]. This technique requires no catheter insertion or contrast agent and provides useful qualitative information on the dynamic filling by the temporal resolution of 200msec in intracranial vessels. However, temporal resolution of this technique is not satisfactory to visualize complex flow patterns such as cerebral aneurysm and AVM. In such a case, temporal resolution of the order of tens of milliseconds is required. To increase the temporal resolution, many 3D protocols have been used various under-sampling schemes in Fourier space. One example is the k-t BLAST technique that reduced data acquisition method allowing for significant accelerations. In this study we present a CINEMA sequence with k-t BLAST that produces high-frame-rate non-contrast time-resolved MRA(CINEMA with High tEmporal ResOlution: CINEMA-HERO). We investigate non-contrast time-resolved MRA with a CINEMA-HERO sequence with feasibility study results in healthy volunteers and cerebrovascular disease patients.

METHODS

Theory and Pulse Sequence: This sequence consists of two major techniques: FAIR and Look-Locker sampling. FAIR is a standard ASL technique that measured the signal from arterial blood at an inversion delay after magnetic labeling. Look-Locker sampling allows monitoring of the temporal dynamics of blood inflow. Imaging was performed with 3D segmented T1-weighted turbo field echo sequence (3D-T1-TFE) with k-t BLAST. Imaging volume was a target volume of 50mm. By combining the above technique, we achieved non-contrast time-resolved MR Angiography at a frame rate of 25 fps (40ms).

Volunteer and patient study: local-IRB approval was obtained and all study participants provided written informed consent. A total of consisted of 8 healthy volunteers and 8 patients were included, approved the study. All examinations were performed on a Philips Achieva 3.0 Tesla scanner and equipped with a 32-element head coil. The image quality of CINEMA was compared to that of TOF-MRA and MRDSA in terms of the depiction of detailed anatomy by two board-certified radiologists independently. Depictions of the detailed anatomy were determined using weighted kappa (K) statistics. CINEMA was implemented with the following parameters: FOV=220×200mm2, Matrix=224×162, 3D acquisition with 50×1mm slices, resolution=1×1×1mm^3, flip angle=10°, TR=4.5ms, TE=2.2ms, k-t BLAST factor=4.0, TI/ΔTI/final TI=80ms/40ms/2.0s, number of acquired time points=25/1.0s. The scan time was approximately 5min.

RESULTS

Volunteer and patient studies were successfully performed, with clear depiction of major intracranial vessels in all studies. Figure 1 shows the results from CINEMA-HERO of a patient with AVM. CINEMA-HERO demonstrated the nidus and the feeding arteries, the right posterior cerebral artery, and subsequent draining into the superficial venous system can be clearly observed with a temporal resolution of 40 msec. Compared with MRDSA, CINEMA-HERO without contrast material was similarly successful at visualizing the branches of the cranial arteries. The inter-modality agreement was excellent (K=0.95, 95% confidence interval [CI]: 0.61-1.0).

DISCUSSION AND CONCLUSION

This study demonstrated the feasibility of the CINEMA-HERO technique in evaluating the anatomic structure and dynamic filling of cerebrovascular disease. With optimized sequence design the acceleration provided by the k-t BLAST, temporal resolution of CINEMA was able to achieve 40 msec. Although further sequence optimization and clinical studies are required, this technique could play an important role in assessing structure and hemodynamics of intracranial arteries without using any contrast agents.

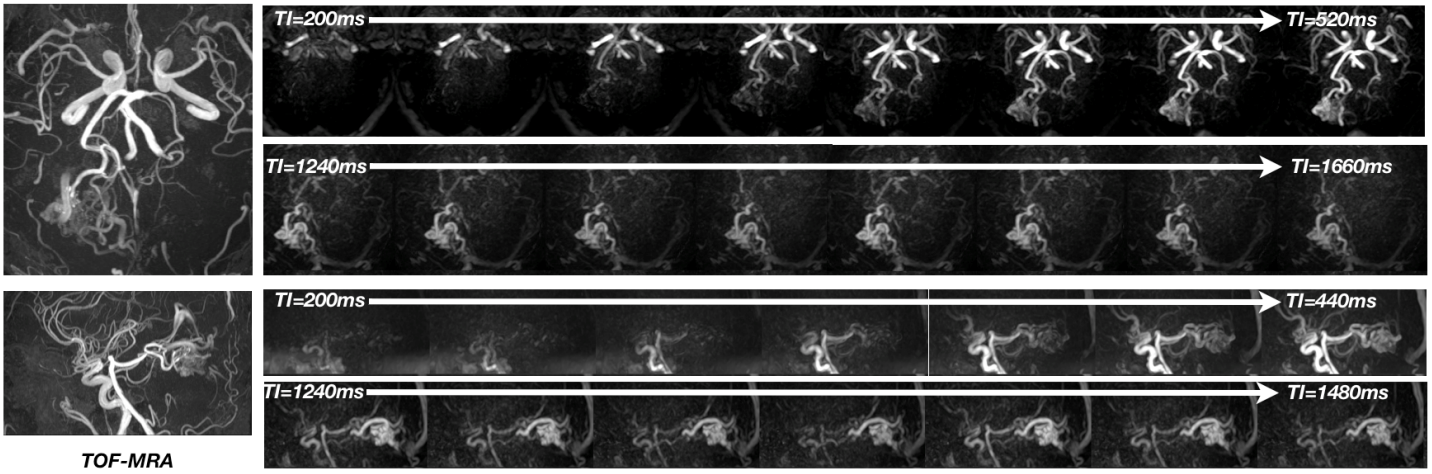

Fig 1. Images from a 29-year-old woman with a medium AVM in the right occipital. The selected transverse MIP images(upper row) and sagittal MIP images (lower row) in CINEMA-HERO show the arterial feeders derived from the right posterior cerebral artery, nidus, and superficial venous drainage.

REFERENCE

[1] Duran M et al. Eur Radiol 2002;12:2957–2964. [2] Hadizadeh DR, et al. Radiology 2008;246:205–213.
[3] Nakamura M et al, 2011;Proc. ISMRM.3878..[4] Tsao J, et al. MRM 2003;50:1031–1042. [5] Kim SG, et al. MRM.1997;37:425-435 45