Non-Contrast-Enhanced MRDSA using Continuous Acquisitions of ECG-Triggered 2D half-Fourier FSE with Partial Flow-Compensation and Parallel Imaging for Assessment of Cerebrovascular Hemodynamics

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INTRODUCTION: Recently, the usefulness of 2D thick-slice contrast-enhanced MR digital subtraction angiography (MRDSA) was reported in an evaluation of hemodynamics of cerebrovascular diseases, however it is essential to use contrast material [1]. We have reported a novel non-contrast-enhanced MRDSA technique, continuous acquisitions of a single slice with multiple phases using ECG-triggered 2D half-Fourier FSE with partial flow-compensation and parallel imaging [2]. In this study, we have optimized the technique and evaluated the feasibility of the technique in patients with cerebrovascular diseases.

METHODS and MATERIALS: Downstream pulse wave transmits from ascending aorta to cerebral arteries after cardiac ejection. Using a short echo space half-Fourier FSE, arteries are depicted in low signal intensity during early systole and in high signal intensity during diastole, which is because fast arterial flow during systole has intrinsic dephasing effects. Therefore, when the arterial signals are observed using a short ECG interval between the single-shot images during the phase of a pulse wave transmission, low signal or flow-void signal would transmit within vessels from the proximal to the distal region.(Fig.1)

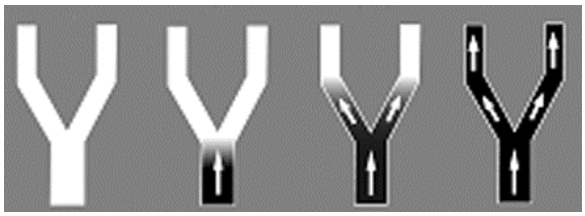

Fig.1 Flow void transmission

All MR examinations were performed using a 1.5-T clinical imager (EXCELART, Toshiba, Tokyo), using a QD head SPEEDER coil. Two-dimensional (2D) single-shot thick slice images in multiple cardiac phases were acquired in a coronal or sagittal plane using ECG-triggered half-Fourier FSE with partial flow-compensation and parallel imaging. Acquisition parameters are 1 shot, TR of 3 or 4 R-R intervals, ETS of 4 msec, TEeff of 8 msec, matrix of 192x256, a 50-70 mm thick slice, parallel imaging factor of 1.8-3.0 and FOV of 25x25 cm. Multiple cardiac phases, a total of 50-130 phases, were acquired using short interval between the images. A total acquisition time was about 2-5 minutes. After acquisitions, dynamic subtractions of a diastolic image depicted in bright blood arteries from the following systolic images provide demonstration of hemodynamic flow.

In order to observe the detailed transformation of cerebral artery signal change, an R wave increment delay time was varied from 3 to 15 msec in 4 healthy volunteers. Ten patients with intracranial diseases, including 4 arteriovenous malformation, 1 meningioma, and 5 cerebrovascular occulusive diseases, were evaluated to study the feasibility of non-contrast-enhanced MRDSA to provide cerebral flow dynamics information.

RESULTS: The R wave increment delay time was optimized and found that it was necessary to use an increment delay time of shorter than 10 msec to depict cerebral arteries to separate the vessels and assess flow dynamics. In cases with arteriovenous malformation (AVM), the nidus of AVM was demonstrated just following on large portions of the major cerebral arteries on non-contrast-enhanced MRDSA images (Fig 2). However, a tiny nidus was not demonstrated and large vessels overlapped and small arteries were also not clearly visulalized. Fig. 3 shows a case with meningioma. In non-contrast enhanced MRDSA, the signal of tumor gradually increases with time, which indicates a vascular rich tumor. In cases with internal carotid artery (ICA) occlusion, anterior and middle cerebral artery supplied via collaterals of the circle of Willis was appreciated on non-contrast-enhanced MRDSA.

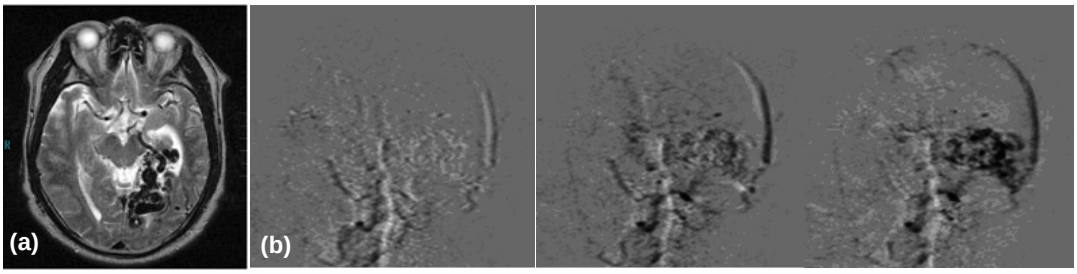

Fig.2 57 y.o. male with arteriovenous malformation **(a)** T2WI **(b)** non-contrast-enhanced MRDSA

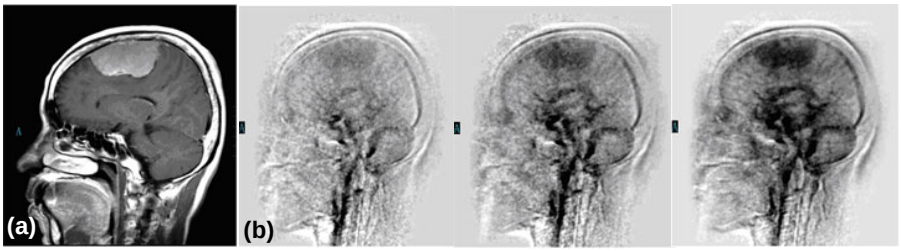

Fig.3 59 y.o. female with meningioma **(a)** Gd-T1WI **(b)** non-contrast-enhanced MRDSA

DISCUSSION and CONCLUSION: Using multiple cardiac phase acquisitions with a short increment delay, non-contrast-enhanced MRDSA-like images were obtained after subtraction without use of any contrast agent. Because subtraction of obtained images with a short increment delay permits observation of drastic signal change of cerebral vessels during the cardiac cycle, this method allows us to observe flow void transmission within the vessels. The increment delay of 5 msec was appropriate to follow the dynamic signal changes in cerebral vessels. In conclusion, natural dynamic flow of cerebral vessels is observed in patients, which helps obtaining additional hemodynamics information using continuous acquisitions of ECG-triggered half-Fourier FSE with partial flow-compensation and parallel imaging without contrast agent.

References: [1] Aoki A, Yoshikawa T, Hori M, et al. Eur Radiol 10 1858-1864, 2000 [2] Miyazaki M, Nakamura K, Yamamoto A, ISMRM p1689, 2003.