Feasibility of pulse wave velocity measurement using ECG-triggered two-dimensional half-Fourier FSE

K. Kuroki[1], K. Nakamura[1], A. Yamamoto[2], R. Nagashima[2], and M. Miyazaki[3]
[1]Department of Radiology, Tobata Kyoritsu Hospital, Kitakyushu, Fukuoka, Japan, [2]Radiology, Tobata Kyoritsu Hospital, Kitakyushu, Fukuoka, Japan, [3]Toshiba America Medical Systems Co., Illinois, United States

INTRODUCTION

Arterial stiffness (AS) increases with age and is enhanced with atherosclerosis. AS can be assessed non-invasively with the use of pulse wave velocity (PWV), which is the velocity of the pulse wave to travel within the arterial system. Although many MR methods for PWV measurement have been proposed, no routine clinical study is available. The purpose of this study is to investigate the feasibility of a non-contrast time resolved DSA technique using ECG-gated two-dimensional half-Fourier FSE to measure PWV [1]

THEORY

Using a short echo-spacing half-Fourier FSE, arteries are depicted in low signal intensity during early systole and in high during diastole, because of dephasing in signals of fast arterial flow. The arterial signal difference in a short cardiac phase interval during pulse wave transmission can be considered as observing as an arterial flow wave. To measure the signal difference in short cardiac phase interval, a single shot half-Fourier FSE with triggering in every 3RR or 4RR interval with an increment triggering delay time of 5-10 ms can be applied as an arterial pressure wave, under the assumption of minimal signal difference between different cardiac cycles.

MATERIALS AND METHODS

All MR examinations were performed using a 1.5-T clinical imager (EXCELART, Toshiba, Tokyo) with an 8-channel QD torso coil. The 2D single-shot images were acquired in the coronal plane with ECG-triggered half-Fourier FSE, TR of 3- or 4RR interval, ETS of 4 ms, TEeff of 32 ms, matrix of 192x256, a 70-mm thick slice, and FOV of 37 cm. Multiple cardiac phases were acquired using a 5 or 10-ms interval between the images starting zero delay from the R wave.

Signal change in the lower extremity artery was measured using an ROI analysis from the time-signal intensity curve. The PWV was calculated using PWV=D/T; where T is a transit time of the signal decrease point in the signal intensity curve and D is a distance between the two ROIs manually measured on the computer screen, as shown in Fig. 1.

An institutional review board approval and informed consent were obtained. Twenty-two subjects were divided into three groups; group A; 6 normal volunteer (aged 22 to 42 years; mean 27.6 years), group B; 11 patients without symptoms or past history of cardiovascular diseases (aged 65 to 99 years; mean 74.1 years), group C; 6 patients with arteriosclerosis obliterans (ASO) (aged 70 to 82 years; mean 71.5 years). In group C, the ankle-brachial index (ABI) of higher than 0.9 was confirmed on the leg opposite side of the leg with a stenosis or occlusion. We evaluated that the relationship of PWV and age in group A and B, alternation of PWV in patients with atherosclerosis in group B and C, and the correlation between PWV and brachial - ankle PWV (baPWV) in group A, B, and C. The baPWV was measured using a volume-plethymographic apparatus (form PWV/ABI; Colin, Co., Ltd., Japan).

RESULTS and DISCUSSION

Figure 2 shows the relationship of PWV and the age of normal subjects. PWV increases linearly with age in the normal subjects (r=0.64). Figure 3 shows the average PWV of healthy subjects and ASO patients without a significant stenosis. The PWV of the ASO patients is significantly higher than that of healthy subjects (13.6±5.4 m/sec, 8.0±2.3 m/sec, respectively; $p<0.05$). Fig4 presents the relationship of baPWV and PWV measurements. A well-correlated phenomenon is observed between the two measurements (r=0.58, $p<0.01$). The PWV can be measured using short interval delay difference of cardiac phases using ECG-triggered half-Fourier FSE. The technique takes a few minutes to acquire the data; therefore, it can be incorporated in the routine clinical study of peripheral run-offs, such as using non-contrast enhanced Flow-spoiled FBI (FS-FBI) [2]. The FS-FBI technique allows excellent depiction of arterial images without administration of contrast materials; therefore, it becomes possible to evaluate functional changes of arteries using PWV and morphology using FS-FBI. Our method allows observation of the regional change of PWV, whereas baPWV permits a rather long path of pulse wave transmission including central artery (aorta) and peripheral arteries. In conclusion, our method allows observation of the local area of arterial vessel stiffness non-invasively.

REFERENCES

1] Nakamura K, Yamamoto A, et al. ISMRM p1356, 2003 2] Miyazaki M, Takai H, et al. Radiology 227:890-896, 2003

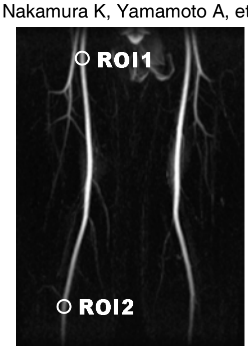

Fig 1 Example of ROIs

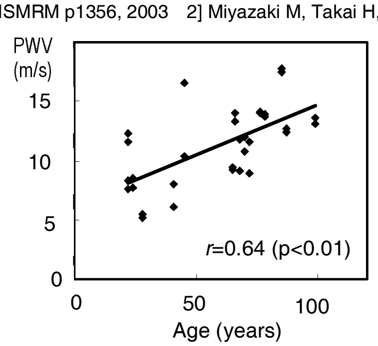

Fig 2 Relationship of PWV and age

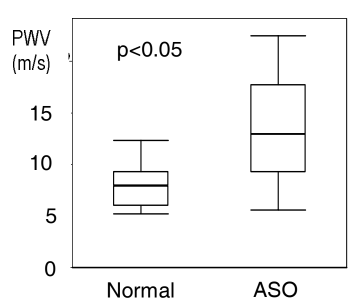

Fig 3 PWV in normal and ASO subjects

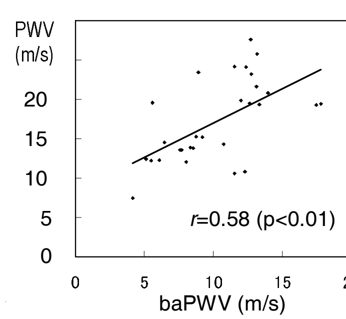

Fig 4 Relationship of PWV and baPWV