

Quantitative Analysis of DCE-MRI to Identify and Characterize Plaque at Early Stages (AHA I-III)

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Background: Atherosclerotic disease is thought to begin shortly after birth. Through the years, plaques grow slowly, with variable morphologic aspects and properties at different stages of development [1]. The American Heart Association (AHA) has established criteria by which plaques are classified according to content and structure [2]. It is important to differentiate young stable plaques with a low extracellular lipid content that are not dangerous (types I-III) from unstable more dangerous types (IV-Vc). However, the molecular mediators of atherosclerosis at type I-III are an area of great interest in basic science. Characterization of plaque using MRI at a very early stage is very important for understanding disease process and choosing appropriate prevention and treatment strategies. Dynamic contrast-enhanced MRI (DCE-MRI) may play an important role to identify and characterize plaque at type I-III. **Materials and Methods:** 7 Watanabe heritable hyperlipidemic (WHHL) rabbits were investigated. The aorta was imaged before and following administration of 0.2 mmol/kg gadolinium dimeglumine (Gd-DTPA, Magnevist; Schering) at 3, 15, 27, 39 minutes on a 1.5 T MRI scanner (Magnetom Espree, Siemens, Erlangen, Germany). All subjects were placed supine, and feet first position. Abdominal respiratory motion was restricted by a towel wrapped around abdominal area and body matrix coil was placed underneath rabbit at the center of the magnet. The protocol included a multi-planar localizer and a two-dimensional (2D) time-of-flight (TOF) sequence to aid in the localization of the descending aorta, the renal artery bifurcation should be covered as an anatomic marker for MRI. Multi-slice dark blood 2D TSE (FOV = 200 × 160 mm; TR/TE= 900/ 9 ms; ETL = 15, Resolution = 0.4 × 0.4 × 3 mm³) with inflow/outflow saturation bands was conducted with 7 axial slices (3 mm thickness, 100% interslice gap) per scan and 2 interleaved scans per segment. Diseased aortic wall signal to noise (SNR) was measured and comparison with MR-matched histological sections. A 3D FLASH T1w in-plane imaging was also performed (FOV = 196 × 370 mm; TR/TE= 233/4.14 ms; Resolution = 0.7 × 0.7 × 0.7 mm³). The corresponding H&E staining histology slices were used to classify plaques according to the AHA criteria; RAM11 was used for immunohistochemical demonstration of rabbit macrophages. MR images and histological slices were classified independently by two radiologists and a pathologist, respectively, on the basis of the AHA classification. **Results:** The vessel lumen appeared dark on both pre- and post-contrast injection. However, pronounced enhancement occurred in the aorta wall of all WHHL rabbits following contrast injection and vessel wall exhibited a mild concentric thickening. A sample of 3D sagittal image of the descending and abdominal aorta obtained from a rabbit is shown in Fig.1. 2D T1w slices perpendicular to aorta showed areas with higher signal intensity of the vessel wall compared with plain MRI (Fig. 2). These plaques exhibited various histological features such as isolated macrophages, foam cells and small lipid cores without calcification which are type I-III plaques classified by AHA criteria. Following Gd injection, each plaque was analyzed in 6 sections on histological sections and on MR images. Although the pattern of enhancement was circular in all axial MRI images analyzed (N = 98), measurement of signal intensity (SI) was related to the number of macrophages (Fig. 2). **Conclusion:** DCE-MRI can be used to identify and characterize Plaque at type AHA I-III). **Acknowledgements:** We sincerely thank Masashi Shiomi, Ph.D. (Institute for Experimental Animals Kobe University School of Medicine) for kindly providing WHHL rabbits. **Refs:** 1. Stary HC. Arteriosclerosis 1989; 9:119-132. 2. Stary HC, et al. circulation 1995; 92:1355-1374.

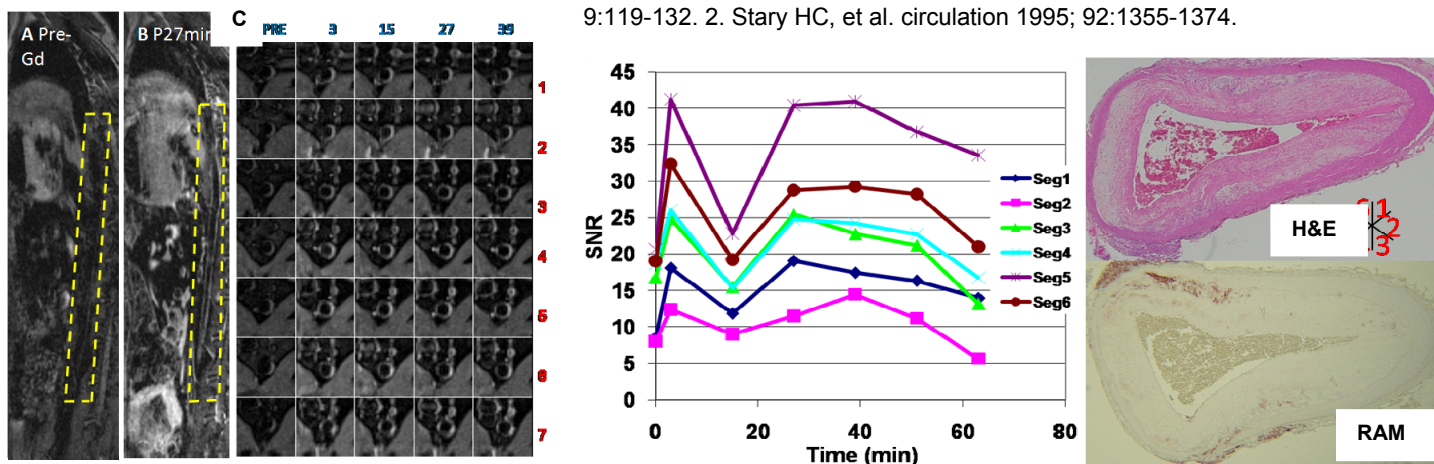


Fig.1: In vivo DCE-MR sagittal and axial images. A, pre-Gd; B, after Gd injection, heterogeneous plaque enhancement along with aorta length. C, selected 7 slices at different time points (rows) at pre, 3, 15, 27, 39 post Gd injection (columns).

Fig. 2: In vivo 2D TSE image from Fig. 1C slice 7, and H&E, RAM 11 sections were divided into 6 quadrants for analysis of the relation between SNR (right panel). The amount of macrophages and the appearance of MR image correlates closely with the matched RAM 11 section.