T1 Contrast Generation in Coronary MRA without the use of Contrast Agents

M. Stuber[1], E. Spuentrup[2]

[1]Radiology, Johns Hopkins University, Baltimore, MD, United States, [2]Radiology, RWTH Aachen, Aachen, Germany

Introduction: Contrast enhancement between the coronary lumen blood-pool and the surrounding tissue is a most important determinant in contemporary coronary magnetic resonance angiography (MRA). Bright-blood visualization has been obtained using magnetization transfer pre-pulses, T2Prep, as well as extracellular and intravascular T1-lowering contrast agents. While the natural T2 differences between blood and myocardium support an effective contrast generation using the T2Prep, the natural T1 values of blood and myocardium are too close to permit an efficient T1 contrast generation without the use of contrast agents. In the present work, a novel endogenous T1 contrast enhancement mechanism without the need for contrast agents is introduced and first in-vivo results are presented.

Methods: *Concept:* T1 contrast generation for coronary MRA without the use of contrast agents (Figure 1) has been developed using a non-selective inversion of the magnetization that is immediately followed by a cylindrical re-inversion of the magnetization in the blood-pool of the ascending aorta. A time delay (TL, Figure 1) between the non-selective inversion and the imaging part of the sequence simultaneously allows for signal-nulling of the myocardium and in-flow of the re-inverted, fully restored aortic blood-pool magnetization into the coronary arteries, where imaging is performed. Therefore, a high signal intensity is expected from the blood flowing into the coronary arteries and signal attenuation for the myocardium is predicted. *Implementation:* The Technique was implemented on a commercial 1.5T Philips Intera system. A non-selective inversion pulse was combined with a highly selective cylindrical aortic re-inversion of the blood-pool magnetization (Figure 1). For the 2D selective cylindrical radiofrequeny (RF) pulse oriented along the ascending aorta, a 180Deg excitation angle, 12 cycles in k-space, and an individually adjusted diameter of the cylindrical excitation was used. The TL was calculated using the heart-rate dependent Fleckenstein formula (1) in which a T1 of 850ms was used for signal-nulling of the myocardium (TL=300..400ms). This dual-inversion pre-pulse scheme was combined with a real-time navigator for respiratory motion suppression (5mm gating window), a fat saturation pre-pulse, and a 3D volume-targeted radial SSFP imaging sequence (360mm FOV, 512 matrix, 75% angular coverage, 12 3mm slices, 16 profiles per RR interval, TR/TE=7.2/3.6ms (acquisition window=115ms), Alpha=120Deg). The trigger delay (TD) was individually adjusted to collect the image data in a diastolic period of minimal myocardial motion.

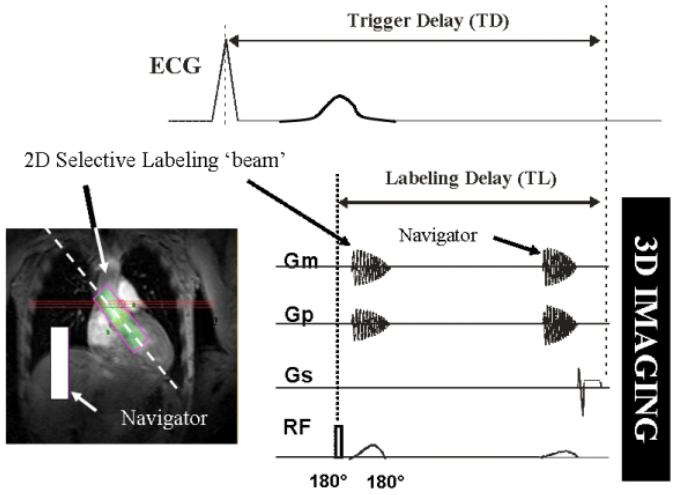

Figure 1 *Localization of cylindrical aortic inversion pulse (left) and imaging sequence (right) used for endogenous T1 contrast enhanced coronary MRA. The time delay TL allows for simultaneous signal-nulling of the myocardium and in-flow of the re-inverted blood-pool magnetization into the coronary arteries.*

Results: In Figure 2, two coronary MRA acquired using the endogenous T1 contrast generation concept are displayed. In Figure 2A, the ascending aorta (Ao), the left coronary circumflex (LCX) and the left anterior descending (LAD) including a more distal branch display with high visual contrast. The myocardium is effectively suppressed (dashed arrow, Figure 2A) as predicted while some residual signal is seen in the region of the right ventricular outflow tract and the anterior chest. Similar results can be observed in Figure 2B, where the right coronary artery (RCA) and the LAD appear signal enhanced. Again, the myocardium is displayed signal-suppressed (dashed arrow), while an enhanced signal can also be seen in the region of the great cardiac vessels and the liver. Scanning time per 3D data set during free-breathing is 6-7min.

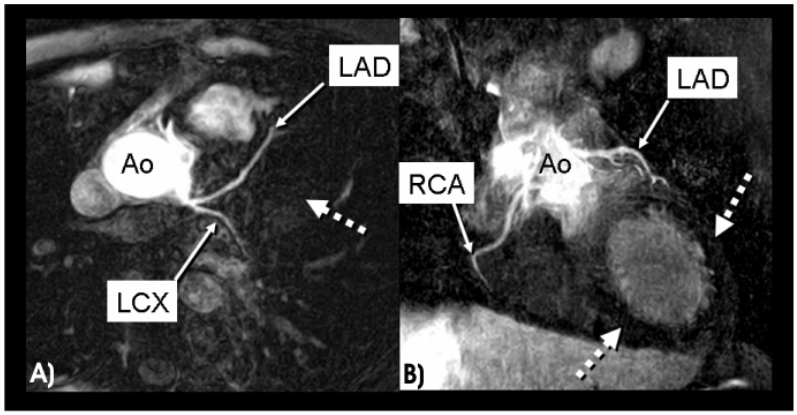

Figure 2 *Images acquired with dual-inversion endogenous T1 contrast enhancement in combination with a real-time navigator for respiratory motion correction and a 3D radial SSFP imaging sequence. Left coronary circumflex=LCX; Aorta=Ao; left anterior descending=LAD; right coronary artery=RCA.*

Discussion: The proposed method provides a new T1 dependent endogenous bright-blood contrast enhancement mechanism for coronary MRA. In principle this dual-inversion concept can be combined with all the contemporary coronary MR imaging sequences including segmented k-space gradient echo, spiral, EPI, SSFP, and radial SSFP with and without breath-holding. Hereby, the signal from the myocardium can very effectively be suppressed while the blood-pool magnetization is fully restored. The present approach depends on in-flow of the re-inverted blood-pool magnetization into the coronary arteries - similar to previously reported arterial spin labeling techniques. However, when compared to spin-labeling approaches, no subtraction is needed, susceptibility to mis-registration and subsequent subtraction artifacts is removed, and scanning time is abbreviated by a factor of 2.

(1) Fleckenstein et al.: Radiology 179(2), 499-504, 1991.