Contrast Enhanced Coronary MR Angiography using Vasovist ® - Comparison with T_2 prepared bSSFP Acquisition in Pigs

C. Warmuth[1], M. Reinhardt[2], and J. Schnorr[3,4]

[1]Department of Molecular MR Imaging, Siemens Medical Solutions, Erlangen, Germany, Germany, [2]Research Laboratories, Schering AG, Berlin, Germany, [3]Department of Radiology, Charité Universitätsmedizin Berlin, Berlin, Germany, [4]Research, Ferropharm GmbH, Teltow, Germany

Introduction The first studies using MS-325 (Vasovist, Schering AG, Germany) for angiography of the coronary arteries have been performed in the late 1990's [1,2]. It was shown, that contrast enhanced acquisitions in combination with inversion recovery preparation have higher contrast-to-noise ratios (CNR) than T_2 prepared acquisitions, if gradient echo sequences are used. Both contrast enhanced and native coronary angiographies benefit from high-SNR balanced steady-state free precession (bSSFP) readout, which is superior to gradient echo readout [3, 4]. The aim of this study was to compare the best currently available imaging techniques. A pig model was chosen, because plasma binding and relaxivity of Vasovist are closest to that in humans [5].

Materials & Methods All experiments were performed on a 1.5 T MR system (Magnetom Avanto, Siemens). In a first step, the contrast kinetics of Vasovist was determined for a clinical dose of 30 µmol Gd/kg by measuring the T_1 relaxation times of blood and myocardium during the first 60 minutes after application. Single slice inversion prepared segmented gradient echo images (9 lines per heart beat, α=15°, TE 1.9 ms) with TI's of 30, 50, 80, 100, 150 and 200 ms were acquired in breathold at different points in time after the contrast injection. Regions of interest were drawn in blood and myocardium and the respective T_1 values were determined by a least squares fit. In a second experiment, inversion prepared thin slab 3D bSSFP breathhold acquisitions were performed repeatedly after application of the contrast medium. The TI's ranged from 200 to 400 ms here, the bSSFP readout had an echo time of 1.7 ms, a bandwidth of 965 Hz/pixel with 9 linear ramp dummy pulses and 25 image lines acquired per heart beat using a 60° flip angle. Regions of interest in blood and muscle (representing myocardium) were drawn to determine CNR values. These were compared to the CNR of an unenhanced acquisition of equal scan time that incorporated a 40 ms T_2-prep pulse. Finally, an appropriate inversion time was chosen for whole heart acquisition. This TI should be optimal for the first 15 minutes after contrast application. Navigator gated 3D whole-heart acquisitions were performed with and without Vasovist and the CNR was determined.

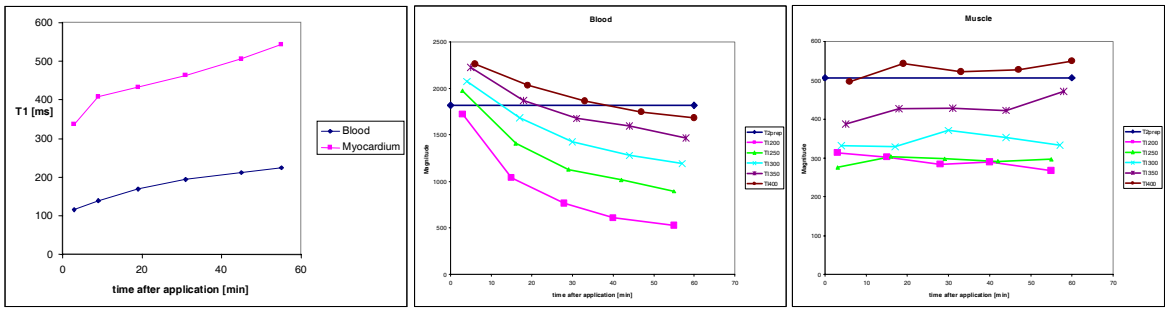

Figure 1: T_1 relaxation time and magnitude signals of pig blood and muscle during the first 60 min after application of Vasovist

Results & Discussion Shown in figure 1 are plots of the T_1 relaxation times of blood and myocardium after contrast agent application. At the clinical dose, blood T_1 starts at 116 ms directly after application. That part of Vasovist that is not bound to albumin is freely diffusible and may leave the blood at the capillaries. It causes a shortening of myocardium T_1 to about 340 ms after injection. The contrast agent is slowly extracted from the blood pool. As can be seen in figure 1, the measured blood signal is dependent on the changing T_1 of blood, whereas the magnitude signal of muscle stays almost constant for a certain TI. As a result, the CNR of a Vasovist enhanced acquisition (TI=300 ms) directly after contrast agent injection is about 40% higher compared to a native T_2 prepared one. At about 20 minutes post injection, both techniques have equal CNR. Thereafter, inversion preparation destroys more signal than it gains contrast. In figure 2 whole heart acquisitions with equal scan time of 12 minutes and 1 mm isotropic resolution are shown. Vasovist enhanced coronary MRA with TI=300 ms had 34% higher CNR. Another observation was an improved fat suppression, most probably resulting from the additional inversion preparation; both angiographies were done using the same shim. A disadvantage is that venous blood is not suppressed in IR bSSFP. In humans, three effects could further improve the performance of Vasovist enhanced acquisitions: (1) plasma binding and relaxivity are slightly higher [5], (2) the heart rate is lower so that the resulting longer TI gives better contrast and (3) the extraction from the blood is slower. In conclusion, coronary angiography benefits from application of Vasovist in the first 20 minutes. CNR limited breathhold acquisitions performed immediately after injection showed the highest improvement.

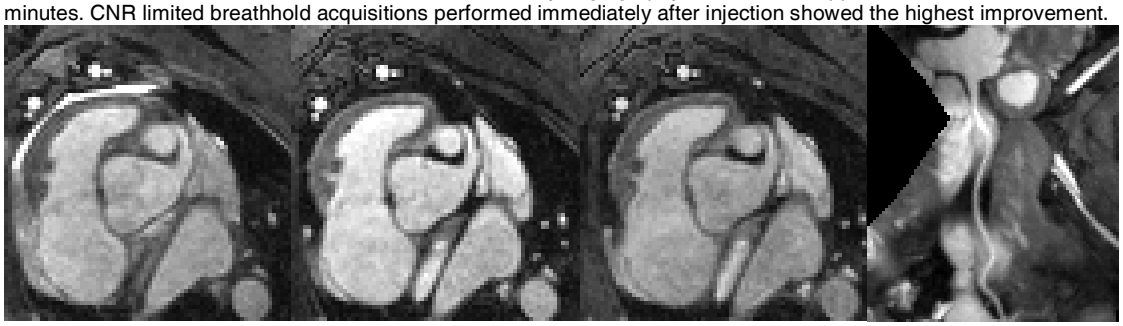

Figure 2: Whole-heart coronary angiography acquisitions with identical level/window. (1) T_2-prep,CNR 6.6 (2) 2-13 min p.i., CNR 8.8, (3) 14-25 min p.i. CNR 6.9. Note the better suppression of fat e.g. surrounding the RCA and of the pericardial effusion. (4) Curved thin slab MIP of the RCA

References

[1] Li D et al., MRM 39(6): 1014-8, 1998
[2] Stuber M. et al., JMRI 10(5): 790-9, 1999
[3] Nassenstein K et al., Rofo 178(5):508-14, 2006
[4] Deshpande V. Et al., MRM 46(3): 494-502, 2001
[5] Eldredge, H et al., Invest Radiol 41(3): 229-243, 2006