Steady State Free Precession (SSFP) Cardiac 1st Pass Perfusion MRI: Left Ventricular Blood Pool Saturation Effects and Considerations at 1.5T

J. Vogel-Claussen[1], K. Kitagawa[2], J. A. Lima[2], and D. A. Bluemke[1,2]

[1]Department of Radiology, Johns Hopkins Hospital, Baltimore, MD, United States, [2]Department of Cardiology, Johns Hopkins Hospital, Baltimore, MD, United States

Introduction: Absolute quantification of myocardial perfusion is necessary to identify diffuse myocardial perfusion abnormalities. Traditionally gadolinium contrast is administered on a weight-based dosing scheme (mmol/kg) based on delayed kinetics of the distribution volume(1). The purpose of this study was to evaluate the impact of this traditional weight-adjusted dosing scheme on the myocardial blood pool contrast concentration for quantitative analysis of first pass perfusion MRI.

Material and Methods: A steady state free precession (SSFP) resting myocardial perfusion protocol was implemented on a 1.5T magnet (Siemens Avanto, Erlangen, Germany). Scan parameters per slice were TR 2,4ms / TE 1.0 ms, 50° flip angle, FOV 36x 27cm, matrix 192x115, acquisition duration 150 msec, slice thickness 8mm and an acceleration factor of 2 (GRAPPA). 3 short axis and 1 horizontal long axis slice were acquired with a temporal resolution of 2RR. A dilute bolus (1:10) matching the volume amount of the non-diluted bolus of gadopentetate dimeglumine (Magnevist, Berlex, Montville USA) was injected intravenously through an antecubital vein at 5cc/sec to acquire low dose perfusion images followed immediately by a 20cc normal saline flush at 5cc/sec. Images were acquired for 60 sec during the first pass of the contrast agent. Then a second non-diluted contrast injection was performed using a weight-based dosing scheme (0.075mmol/kg) at the same injection site, using the same injection algorithm, perfusion sequence and slice position. The data were analyzed using a two compartmental perfusion model (Aze Ltd., Tokyo, Japan). K1(transfer constant from the blood of the left ventricular cavity to the myocardium), the myocardial blood flow (MBF) and the left ventricular blood pool contrast concentration were calculated using the low dose test bolus to adjust for saturation effects.

Results: Doses from 8-16ml (concentration, 0.05mol/l diluted bolus, and 0.5mol/l non-diluted bolus) of gadopentetate dimeglumine were used for the weight-based dosing scheme (0.075mmol/kg). 15 patients (10 men/ 5 women, mean age 45, range 18-77 years) with a clinical referral for a cardiac MRI evaluation were prospectively included in the study. The final diagnoses were ischemic heart disease (n=2), infiltrative cardiomyopathy (2), hypertrophic cardiomyopathy (4), myocarditis (2), aortic stenosis (1) or normal (4). The mean left ventricular ejection fraction was 58.2% (range 24-76%). With test bolus correction the mean K1 was 0.44±0.18 ml/min/per gram myocardium and the mean left ventricular wall MBF was 1.0 ±0.86 ml/min per gram myocardium. For lower contrast doses (≤11ml gadolinium DTPA), with increasing contrast dose there was an increase in the measured left ventricular blood pool contrast concentration. However, for the higher contrast dose range (>11ml gadolinium DTPA) with increasing contrast dose there was a decrease in the measured test bolus adjusted LV blood pool contrast concentration. (Figure 1).

Conclusion: Traditional weight-adjusted dosing scheme for quantitative analysis of first pass SSFP perfusion MRI using 0.075mmol/kg does not result in uniform left ventricular blood pool contrast concentration. At doses >11ml gadopentetate dimeglumine the T2 effects appear to artificially decrease the measured LV contrast concentration, which cannot be fully corrected by the test bolus. A fixed amount (<11ml) of a gadolinium based extracellular contrast agent may be more reliable than weight adjusted dosing for 1st pass SSFP perfusion MRI.

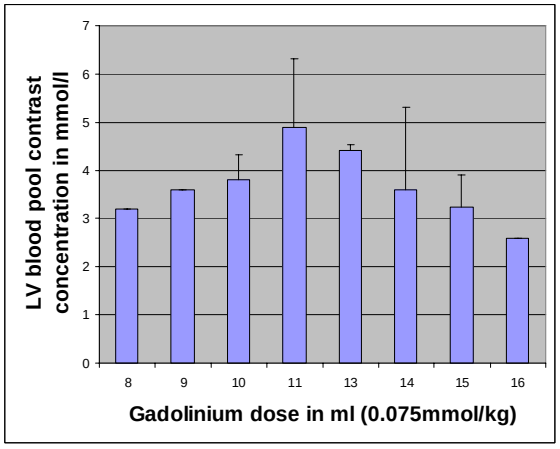

Figure 1a.

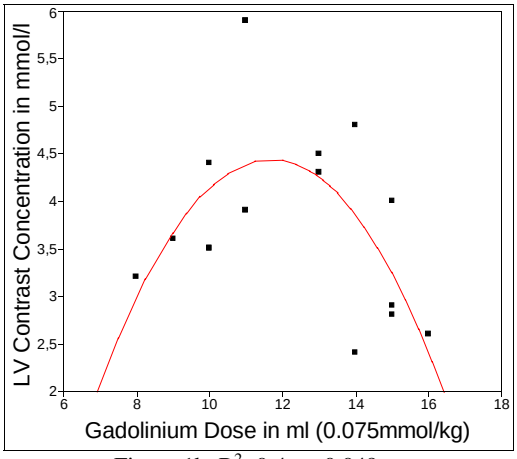

Figure 1b. R^2=0.4, p=0.049

Figure1. For lower contrast doses (≤11ml gadolinium DTPA) using a weight-based dosing scheme (0.075mmol/kg) there was an increase in the measured left ventricular blood pool contrast concentration with increasing contrast dose (A and B). However, for the higher contrast dose range (>11ml gadolinium DTPA) there was a decrease in the measured test bolus adjusted LV blood pool contrast concentration with increasing contrast dose (A and B). Figure 1B curve fitting: Polynomial Fit 2nd degree. LV Contrast Concentration in mmol/l = 5,9 - 0,13 * x - 0,11 * x^2.

1. Utz W, Niendorf T, Wassmuth R, Messroghli D, Dietz R, Schulz-Menger J. Contrast-dose relation in first-pass myocardial MR perfusion imaging. J Magn Reson Imaging 2007; 25:1131-1135.