Determination of Optimal Injected Gadolinium Concentration for Catheter-Based Intra-arterial Gadolinium-Enhanced True-FISP MR Coronary Angiography

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Introduction: MRI-guided endovascular procedures employ catheter-based intra-arterial (IA) injections of gadolinium-chelates (Gd) for rapid MR angiography (MRA), while limiting the amount of injected contrast agent. A previous study determined the optimal concentration of injected Gd for IA coronary MRA using gradient echo imaging (1). In that study, Gd levels over the optimal concentration resulted in signal loss due to the decrease in T2* as T1 decreased. True fast imaging with steady-state precession (True-FISP) may be used as an alternative method to boost signal for IA coronary MRA (2), but the optimal injected Gd concentration using this approach is unknown. In swine, we determined the optimal injected Gd concentration for coronary signal-to-noise-ratio (SNR) using 2D projection magnetization-prepared True-FISP.

Methods: We percutaneously placed vascular sheaths in the femoral arteries of six swine (23–34 kg). After preliminary x-ray coronary angiography, the coronary catheter was removed and each pig transferred to a 1.5T Sonata MRI scanner (Siemens, Erlangen, Germany). Under real-time MRI guidance (2), we used 6-F Judkins coronary catheters (Cook, Bloomington, IN) to engage the right (n = 2 pigs) and left (n = 4 pigs) coronary arteries. Once each coronary artery was engaged, we performed electrocardiographic-triggered magnetization-prepared 2D True-FISP coronary MRA using injections of 4%, 8%, 10%, and 12% Gd (diluted with saline by volume). Conditional randomization of injection order was used to reduce injection order bias. For each concentration, we injected 3 – 4 mL of each dilute Gd level at 1 mL/s. We performed a total of 44 separate injections (4 different Gd concentrations x 11 separate series of injections) in the 6 pig experiments. Typical imaging parameters were: TR/TE/flip angle = 3.6 ms/1.5 ms/70^0; FOV = 120 x 400 mm^2; acquisition matrix = 131 x 512; slice thickness = 40 mm; in-plane spatial resolution = 0.9 x 0.8 mm^2. Magnetization preparation consisted of a train of low flip angle pulses followed by 180^0 inversion pulse and inversion time of 50 ms (2).

We used regions-of-interest (ROI) to measure signal within the intermediate portion of each injected coronary artery and in air. SNR was calculated from these ROI measurements. We assessed mean SNR values for each injected Gd concentration using two way analysis of variance, with Bonferroni's method for pairwise multiple comparisons. Alpha was set at 0.05.

Results: The targeted coronary artery was catheterized under real-time MRI guidance in all pigs. 2D projection magnetization-prepared True-FISP successfully depicted the coronary arteries in all 44 injections. Mean SNR, standard errors, and p values for each injected Gd concentration are shown in the **Table**. 4% injected Gd concentration had significantly less SNR than the other tested injection concentrations ($p < 0.05$). There were no statistically significant differences between the other injected Gd concentrations. The **Figure** depicts a sample series of comparisons in the same pig.

Table. Mean SNR, SEM, and p values for each injected Gd concentration.

Injected [Gd]	Mean SNR	SEM	p value
4%	7.2	0.49	< 0.05
8%	8.8	0.47	NS
10%	9.5	0.38	NS
12%	8.8	0.41	NS

Conclusions: In swine, catheter-based IA Gd-enhanced coronary MRA using magnetization-prepared True-FISP is feasible. The ideal Gd concentration should maximize SNR while limiting the total Gd dose. Using this criteria, 8% injected Gd concentration is preferred to the other tested concentrations. This dilution produces significantly greater SNR than 4%, while minimizing the injected dose of contrast agent.

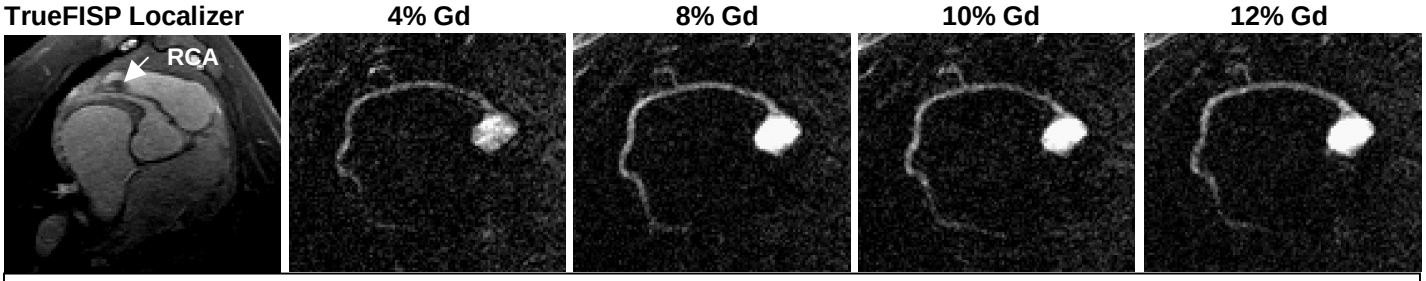

Figure. Comparison transverse oblique images of right coronary artery (RCA) in same swine. Magnetization-prepared TrueFISP depiction of RCA is superior for 8%, 10%, and 12% injected Gd compared to 4% injected Gd. SNR for 4% injected Gd was significantly less than for other injected concentrations.

References:

(1) Green JD, et al. Radiology 2003; 226:272-277.

(2) Omary RA, et al. Circulation 2003; 107:2656-2659.