

Comparison of Intraarterial MRA at 3.0T with X-ray Digital Subtraction Angiography to Detect Renal Artery Stenosis in Swine

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Introduction

3D magnetic resonance angiography (MRA) detection of renal artery stenosis (RAS) has a sensitivity >90% [1] when using intravenous (IV) gadolinium-based contrast agent (Gd) on 1.5T clinical MRI scanners. However, MRA can still overestimate degree of stenosis due to potential loss of signal in a tight stenosis [2]. In swine, catheter-directed MRA of RAS using intraarterial (IA) injection of Gd at 1.5T was shown to be as accurate as IV Gd, using x-ray digital subtraction angiography (DSA) as a gold standard [3]. However, in that study, percent stenosis measurements using IA or IV MRA images were still slightly higher than DSA measurements, suggesting persistent overestimation of degree of stenosis even with IA Gd administration. The potential benefits and accuracy of catheter-directed IA MRA of RAS at 3.0T remain unknown. We tested the hypothesis that catheter-directed IA MRA at 3.0T accurately measures RAS in a swine model, compared to x-ray DSA. This study was performed before and after percutaneous transluminal angioplasty (PTA) of the RAS.

Materials and Methods

We surgically induced a hemodynamically significant (>50%) RAS in a single renal artery in 6 pigs using reverse cable ties [3]. One to two weeks after cable tie placement, each pig underwent x-ray DSA and MRI (3.0T Trio MRI scanner, Siemens, Erlangen, Germany) before and after renal PTA.

For x-ray DSA, a conventional 5-F multi-sidehole angiographic catheter was placed in the abdominal aorta under fluoroscopic guidance. Pre and post-PTA x-ray DSA of the RAS was obtained using iodinated contrast agent (Omnipaque 350, Amersham Health, Princeton, NJ). We then performed x-ray guided PTA using conventional methods.

For MRA, images were acquired using an 8-channel cardiac array coil. To define vessel positions with accuracy, a coronal 3D time-resolved IA contrast-enhanced MRA of the abdomen was acquired [1.1 x 1.1 x 4.2mm voxels, 280 x 280 x 50mm FOV, 256 x 256 x 20 matrix, 3.0 s/frame, TR/TE=3.61/1.11ms, 25° flip angle, 560 Hz/px, 6/8 in-plane and through-plane phase encoding partial Fourier, 2x in-plane generalized autocalibrating partially parallel acquisitions (GRAPPA) [4]

with 24 reference lines, 3 time-resolved imaging of contrast kinetics (TRICKS) [5] segments]. Through a catheter placed in the abdominal aorta, 40mL of an 8% Gd-based contrast agent (Magnevist, Berlex, Wayne, New Jersey), was injected at 6mL/s with a power injector.

To measure the RAS using DSA and MRA images, pre and post-PTA MRA maximum intensity projection (MIP) and DSA images were analyzed on a computer by the full width at half maximum values (FWHM) method. Percent stenosis was measured as: $[1 - (\text{FWHM at stenosis} / \text{FWHM at proximal artery})] \times 100$. We compared percent stenosis measurements between x-ray DSA and MRA using a paired t-test. Correlation between x-ray DSA and MRA measurements of percent RAS was assessed using linear regression. Statistical significance was set at $\alpha=0.05$.

Results

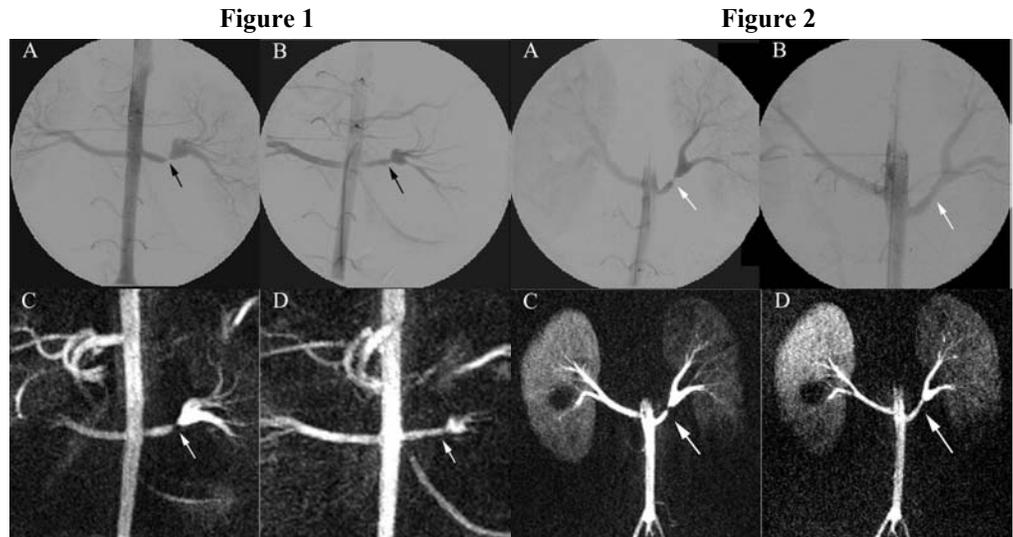
In 6 pigs, we successfully surgically induced 6 RAS (4 left and 2 right RAS). Using DSA and MRA techniques, we imaged all 6 RAS both pre and post PTA (Figures 1, 2). On x-ray DSA, stenoses ranged from 60%-85% (pre-PTA) to 4%-35% (post-PTA). RAS MRA measurements ranged from 53%-83% (pre-PTA) to 14%-38% (post-PTA). No statistically significant difference was detected between DSA and MRA for either pre or post-PTA RAS measurements (Table 1). MRA RAS measurements correlated closely ($p < 0.01$) to DSA measurements with $r^2 = 0.92$ (95% confidence interval, 0.86-0.99) (Figure 3).

Discussion

In this animal study, the accuracy of catheter-directed IA MRA for detecting RAS using a clinical 3.0T MRI scanner was equivalent to conventional x-ray DSA. We successfully applied the TRICKS technique to IA MRA, rather than using conventional IV Gd injections. The combination of IA Gd administration, the use of TRICKS, and/or the use of a 3.0T MRI scanner may have all increased signal at the level of RAS, allowing for a more accurate stenosis measurement with less overestimation. As more hybrid x-ray DSA/MRI units are disseminated, these IA MRA studies at 3.0 T can be validated in humans, typically in the setting of renal artery endovascular interventions.

References

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Figures 1, 2: Representative DSA and MRA images of a unilateral RAS pre and post PTA from two pigs. All images in one figure are from the same pig. A&B) pre and post DSA images. C&D) pre and post MRA images. RAS is identified with an arrow.

PTA	DSA (% Stenosis)	MRA (% Stenosis)	p Value*
Pre-PTA	69 ± 11	69 ± 10	0.99
Post-PTA	19 ± 13	26 ± 10	0.07

*paired t-test

