MRI Assessment of Renal Function During Endovascular Stenting of Renal Artery Stenosis in Swine

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Introduction

Renal artery stenosis (RAS) is commonly treated with minimally invasive revascularization interventions including percutaneous transluminal angioplasty (PTA) and/or intravascular metallic stent placement [1] based on anatomic degree of stenosis and/or non-radiologic indications of impaired renal function. Anatomic measurement of a RAS, however, does not always correlate with underlying physiologic or functional assessment of renal function [2]. MRI of RAS offers the advantages of assessing both anatomic and functional measurements of renal function [i.e. renal blood flow (RBF), extraction fraction (EF), and single kidney glomerular filtration rate (skGFR)] [3-4]. Although MRI at 1.5T and 3.0T can detect changes in renal function at the time of PTA in a swine model of RAS [5-6], the ability of MRI to detect changes in renal function at the time of intravascular stent placement is unknown. And, with the introduction of hybrid MR-IR suites into the clinical setting where MR assessment of renal function at the time of endovascular stent therapy can be performed, pre-clinical studies assessing the ability of MRI to measure changes in renal function are lacking. We tested the hypothesis that MRI at 1.5T can detect changes in renal function at the time of renal artery stent placement in a swine model of RAS.

Materials and Methods

In this Animal Care and Use Committee approved study, we surgically induced a hemodynamically significant (>50%) RAS in a single renal artery in 6 pigs using reverse cable ties [7]. One to two weeks after cable tie placement, each pig underwent x-ray DSA for anatomic stenosis measurements and MRI (1.5T Sonata MRI scanner, Siemens, Erlangen, Germany) for renal function measurements before and after conventional intravascular placement of a commercially available metallic stent (Herculink Plus, Guidant).

Using a 2-channel body array coil, 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) [8] with 24 reference lines, 3 time-resolved imaging of contrast kinetics (TRICKS) [9] segments] to accurately define vessels. 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.

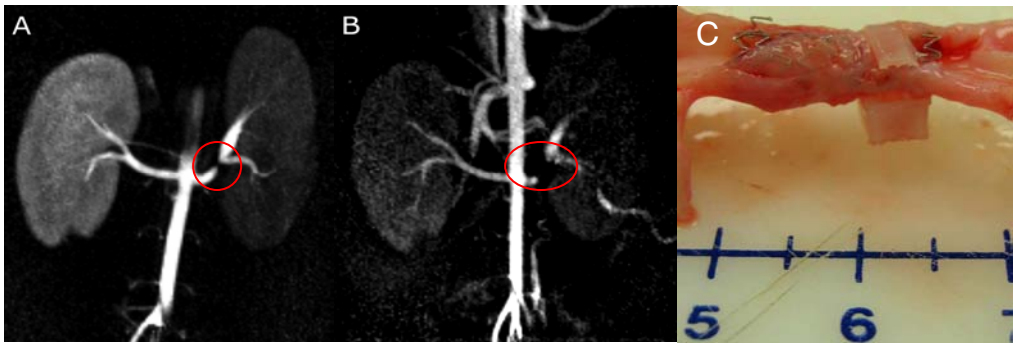

Fig 1: Representative MR and necropsy images pre and post-stent placement. A) pre-stent MR image demonstrating a unilateral RAS (circle); B) post-stent MRI with loss of signal from stent artifact (circle) in left renal artery; C) Necropsy image revealing proper stent placement.

For RBF, a 2D phase contrast sequence (2.5 x 3.1 x 5.0mm voxels, 320 x 160mm FOV, 128 x 51 matrix, TR/TE = 95/3.2ms, 30° flip angle, 400 Hz/pixel, 6 averages, 25 phases, 7 segments, 80cm/s velocity encoding) was used to quantify flow.

For EF, an inversion recovery Look-Locker EPI sequence (2.5 x 2.5 x 5.0mm voxels, 320 x 160mm FOV, 128 x 64 matrix, TR/TE = 23/11 ms, 20° flip angle, 1220 Hx/pixel, 0.98ms echo spacing, 120 phases after inversion pulse) was used to determine T1 of arterial and venous blood.

skGFR was calculated using the following formula:

skGFR = EF x RBF x (1-hematocrit).

We assessed mean and standard deviation of functional (RBF, EF, skGFR) and anatomic (degree of stenosis) measurements using a one-tailed Wilcoxon matched pairs test (p=0.05).

Results

We successfully deployed a metallic stent in all 6 pigs and measured renal function parameters using MRI (**Fig 1**). A small non-statistically significant decrease in mean RBF from pre stent to post stent placement was likely due to metallic stent artifact. Statistically significant changes in stenosis and skGFR measurements were measured pre and post stent placement (**Table 1**).

Table 1: Anatomic and Functional Renal Artery Measurements

Measurement	Pre Stent	Post Stent	p Value
Stenosis on DSA (%)	60±12%	24±16%	**0.02**
RBF (mL/min)	190±114	169±74	0.50
EF	0.19±0.08	0.31±0.17	0.16
skGFR (mL/min)	25±16	41±28	**<0.05**

Conclusion

MRI can detect changes in renal function at the time of intravascular stent placement in RAS in swine. Future clinical translation is now warranted to validate these findings in the clinical setting, particularly in the setting of integrated MR/x-ray DSA hybrid suites.

References

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