Comparison of Catheter-Based Intraarterial Gadolinium-Enhanced MR Angiography with Cross-Sectional TrueFISP for the Detection of Renal Artery Stenosis

R. A. Omary[1], B. E. Schirf[1], J. D. Green[1], R. Tang[1], K. Sato[1], A. Shaibani[1], J. Carr[1], D. Li[1]

[1]Northwestern University, Chicago, IL, United States

Introduction: Catheter-based IA injections of gadolinium-chelates (Gd) can be used during MRI-guided endovascular procedures to provide rapid MR angiographic depiction, while limiting the dose of injected Gd (1). Although this method has similar accuracy to conventional x-ray digital subtraction angiography (DSA) (2), it still does not exploit the ability of MRI to view blood vessels in cross section. We tested the hypothesis that high-resolution 2D cross-sectional true fast imaging with steady-state precession (TrueFISP) improves detection of renal artery stenosis over 3D IA fast low angle shot (FLASH) and inversion recovery (IR)-FLASH in a swine model of renal artery stenosis.

Methods: In 10 healthy pigs (27 – 43 kg), we surgically placed ameroid constrictors around the renal arteries bilaterally. Three weeks later, animals were transported to the x-ray fluoroscopy suite. Via a percutaneous femoral artery approach, we advanced a 5-F conventional angiographic catheter into the abdominal aorta for x-ray DSA. This DSA was considered the reference standard for subsequent renal artery stenosis measurements.

Animals were then transferred to a 1.5 T Sonata MRI scanner (Siemens, Erlangen, Germany) for comparisons using: a) IA Gd-enhanced 3D FLASH, b) IA Gd-enhanced 3D IR-FLASH, and c) 2D cross sectional TrueFISP without contrast agent. Typical 3D FLASH scan parameters were: TR/TE/flip angle= 4.3 ms/1.8 ms/40^0; FOV = 300 x 300 mm^2; acquisition matrix = 384 x 512; 43 lines per segment; 6 partitions interpolated to 12, slab thickness = 48 mm; in-plane spatial resolution = 0.8 x 0.6 mm^2; and scan time = 9.9 s per image. 3D IR-FLASH sequence parameters were similar, except for an additional 70 ms inversion time, which prolonged scan time to 13.7 s per image. For both FLASH methods, we injected 40 mL of 6-8% Gd at 4 mL/s through the 5-F aortic catheter, yielding 1% arterial [Gd]. Typical 2D TrueFISP parameters were: TR/TE/flip angle= 4.9 ms/1.9 ms/65^0; FOV = 300 x 300 mm^2; acquisition matrix = 512 x 512; single shot; 8 averages; asymmetric sampling; slice thickness = 4mm; in-plane spatial resolution = 0.6 x 0.6 mm^2, and scan time = 20 s.

In blinded fashion, we compared quantitative stenosis measurements obtained with the 3 MRI sequences and DSA using linear regression analysis. Alpha was set at 0.05.

Table. Linear regression comparisons to x-ray DSA.

Technique	Equation	R^2
Cross-sectional TrueFISP	y = 1.02x – 4.6	0.87
3D FLASH	y = 0.77x + 18	0.72
3D IR-FLASH	y = 0.82x + 16	0.66

Results: One pig was used for preliminary experiments and 2 pigs died prior to imaging of undetermined etiology, despite post-mortem examinations. X-ray DSA and 3 MRI sequences were successful in the remaining 7 animals (n = 14 stenoses). TrueFISP more accurately detected renal artery stenosis than either of the 3D FLASH methods. As shown in the **Table**, TrueFISP had the highest R^2 and slope closest to unity. When comparing intercepts, the regression line for TrueFISP significantly differed from FLASH and IR-FLASH ($p < 0.05$). Use of IR background suppression did not improve diagnostic accuracy for 3D imaging. The **Figure** compares sample images between the techniques.

Conclusion: In swine, 2D cross-sectional TrueFISP more accurately detects renal artery stenosis than either 3D IA-FLASH method alone. Cross-sectional imaging can be added to 3D IA-MRA for improved diagnostic accuracy. This combined approach is potentially advantageous during MRI-guided endovascular procedures because TrueFISP can be performed without injecting additional contrast agent.

References:

1. Frayne R et al, J Vasc Interv Radiol 2000;11:1277-1284.

2. Omary RA et al, AJR Am J Roentgenol 2002:178;119-123.

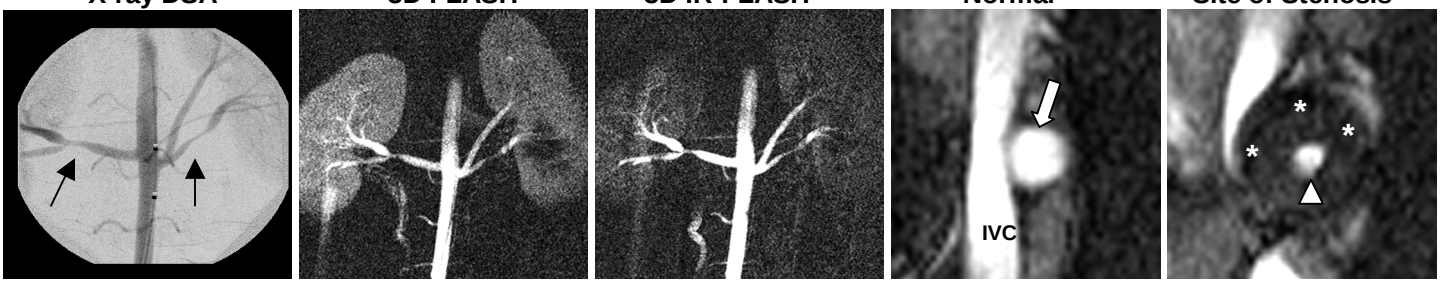

Figure. Comparison images in pig. Bilateral renal artery stenoses are depicted with thin arrows on x-ray DSA. X-ray DSA and FLASH images have same coronal projection. Sagittal oblique TrueFISP images show right renal artery in cross section at normal portion (block arrow) and at stenosis (arrowhead) induced by ameroid constrictor (asterisks).