Introduction
Compared to conventional x-ray angiography, the perceived health benefits of MR-guided endovascular intervention include the ability to provide functional and anatomic MR information, the avoidance of ionized contrast, and the lack of ionizing radiation. In this project, we tested the hypothesis that magnetic resonance imaging can guide the percutaneous treatment of renal artery stenosis in a pig model.

Methods
Ameroid constrictors were surgically placed around the renal arteries in three pigs, producing a gradual hemodynamically significant stenosis. After four to five weeks, each pig received a conventional x-ray aortogram to document the severity of the stenosis. With femoral arterial sheaths left in place, the pigs were transported to the MR scanning suite. A conventional whole-body 1.5 T MR scanner (Signa; General Electric, Waukesha, WI) equipped with EPI-capable gradients was used for this study.

While in the scanner, MRA was performed using a combination of intra-arterial and intravenous contrast-enhanced 3D techniques. Catheters were visualized by filling them with diluted (~20 mM) Gd-DTPA and imaging with 2D and 3D MR spoiled gradient recalled echo (SPGR) techniques. We placed a selective visceral catheter into the femoral vascular sheath and advanced it into the affected renal artery. A nitinol guide wire was used to cross the stenosis. MR depicted the guide wire location as a signal loss, particularly during contrast-enhanced scans. We then exchanged our catheter for an angioplasty balloon that was filled with diluted Gd-DTPA. After expanding the balloon across the stenosis, we obtained final 3D contrast-enhanced MR images.

Stenosis and luminal diameter measurements were compared pre-and post angioplasty.

Results
Using only MR guidance, we achieved technical success in 3/3 pigs (100%). Following angioplasty, the mean reduction in stenosis was 35% (95% confidence interval, 9% to 61%) and the mean increase in luminal diameter was 1.6 mm (95% confidence interval, 0.3 mm to 2.9 mm). Table 1 summarizes our technical results. Figures 1 to 3 illustrate an angioplasty performed under MR guidance.

<table>
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<th>Pig</th>
<th>Stenosis, %</th>
<th>Pre-PTLA</th>
<th>Post-PTLA</th>
<th>Diff.</th>
<th>Luminal Diameter, mm</th>
<th>Pre-PTLA</th>
<th>Post-PTLA</th>
<th>Diff.</th>
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<td>Mean</td>
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<td>1.6±1.2</td>
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Conclusion
Using MR guidance for the angioplasty of renal artery stenosis in pigs is feasible.

Figure 1: A 3D intravenous Gd-DTPA enhanced preliminary MR image demonstrates occlusion of right renal artery and 90% stenosis of left renal artery (arrow) from bilateral ameroid constrictor placement.

Figure 2: 3D MR GRE image shows balloon catheter across left renal artery stenosis. Arrow highlights ameroid constrictor.

Figure 3: 3D intra-arterial Gd-DTPA enhanced MR image following balloon angioplasty to 4 mm. Residual stenosis measures 50%. 

Magnetic Resonance-Guided Angioplasty of Renal Artery Stenosis in a Pig Model: A Feasibility Study

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