Real-Time Magnetic Resonance Imaging-Guided Coronary Catheterization in Swine

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Synopsis: In 11 swine, we performed real-time MRI-guided left coronary artery catheterization from a percutaneous femoral artery approach. A 0.30-inch diameter active guidewire was coaxially inserted within 6 or 7-French Judkins left coronary catheters. The catheter was filled with 4% contrast agent and tracked using an inversion-recovery-prepared spoiled gradient echo sequence at 7 frames/s. The guidewire was tracked using steady-state precession imaging at 9 frames/s. Selective MR coronary angiography with injections of dilute contrast agent was used to verify catheter positioning. Left coronary artery catheterization under MRI guidance was successful in 11/11 pigs (100%).

Introduction: Catheter-based coronary MR angiography is feasible using dilute contrast agent injections (1). The coronary catheterization for these injections has been performed under x-ray (1) or MRI (2) guidance, using surgical carotid artery access. The surgical carotid approach is less technically demanding than the percutaneous femoral artery approach because of the more direct and shorter route to the coronary ostium. An active internal guidewire used in conjunction with a contrast agent-filled catheter is one technique (3) to improve signal detection of endovascular devices, which in turn can be used to improve the spatial and temporal resolution of endovascular device tracking. Using this technique, we tested the hypothesis that MRI can guide coronary artery catheterization in swine via a percutaneous femoral artery approach.

Methods: In 11 pigs, we accessed the common femoral arteries percutaneously. We used 6- or 7-French conventional left coronary Judkins catheters filled with dilute 4% gadolinium (Gd) contrast agent and coaxially inserted 0.30-inch diameter active guidewires (Surgi-Vision, Gaithersburg, MD) as endovascular devices. Imaging was performed on a 1.5 T MRI scanner (Sonota, Siemens, Erlangen, Germany). For catheter tracking, we used a two-dimensional (2D) inversion recovery-prepared spoiled gradient echo sequence (IR-FLASH) at a temporal resolution of 7 frames/s. For guidewire tracking, we used 2D steady-state free precession imaging (TrueFISP) at a temporal resolution of 9 frames/s. A sliding window acquisition was used with both pulse sequences to facilitate these real-time frame rates.

Results: Left coronary artery catheterization under MRI guidance was successful in 11/11 pigs (100%). Fig. 1 illustrates representative images during such a catheterization. The active guidewire was seen as a signal void using TrueFISP, due to the susceptibility artifact from the nitinol. The active guidewire's RF coil depicted surrounding tissue as bright, thereby increasing the contrast between the guidewire and the background tissue. Using IR-FLASH, the dilute Gd-filled catheter was depicted as bright signal with completely suppressed background. Successful coronary catheterization was verified by obtaining MR angiographic images after direct catheter-based injections of dilute 4% - 8% Gd (Fig. 2). These images included rapid vascular roadmaps (Fig 2B, 2D) and higher quality diagnostic coronary MRA (Fig 2F).

Conclusions: MRI-guided catheterization of coronary arteries in swine is feasible in real-time. Use of the femoral artery approach represents a technical advance over previous studies. Selective coronary MRA can be performed with catheter-based injections of dilute contrast agent.

References:

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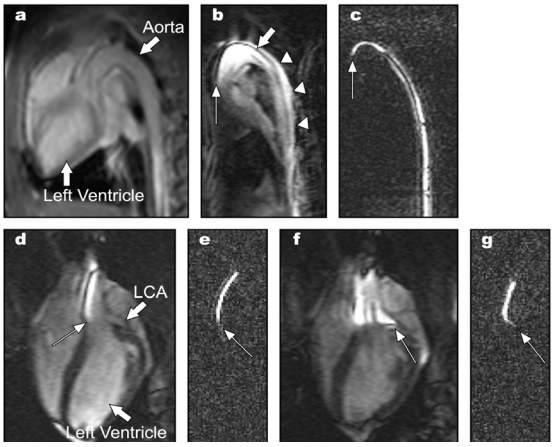

Fig 1. Representative sagittal (**A-C**) and coronal (**D-F**) oblique images of the aorta obtained during MRI-guided left coronary artery catheterization. Thin arrows depict device tips. **A**, Anatomical reference; **B**, **D**, and **F**, TrueFISP guidewire tracking images with dark guidewire susceptibility defect (thick arrow) surrounded by bright adjacent blood vessel (arrowheads); **C**, **E**, and **G**, IR-FLASH catheter tracking. LCA = left coronary artery

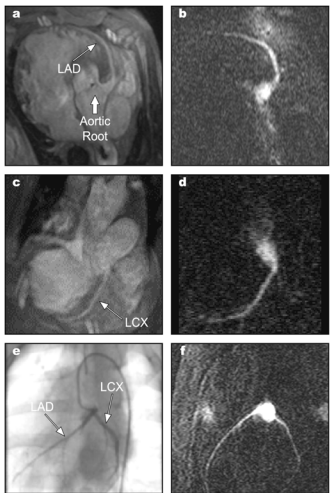

Fig. 2. Transverse oblique reference (**A**) and roadmap (**B**) of left anterior descending artery (LAD); Coronal oblique reference (**C**) and roadmap (**D**) of left circumflex artery (LCX); X-ray (**E**) and MR (**F**) angiogram in 60° left anterior oblique projections.