Real-Time MRI Guided Neurovascular Intervention

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Introduction

Real-time magnetic resonance imaging (MRI) guidance offers many advantages for diagnostic and interventional neurovascular procedures compared to conventional x-ray guidance[1]. For example, the omission of ionizing radiation makes MR-guided endovascular procedures safer to both patients and operators. In addition, gadolinium-based contrast agents exhibit lower nephrotoxicity and allergic potential than iodinated contrast agents[2]. Multiplanar MRA images and online 3D reconstructions facilitate the visualization of complicated vascular anatomy in the head and neck[3]. Furthermore, continuous assessment of tissue viability and brain function during the procedure using diffusion weighted imaging (DWI), perfusion weighted imaging (PWI)[4], and functional MRI (fMRI)[5] provides new dimensions for the treatment of cerebral vascular diseases, particularly ischemic stroke. We carried out a pilot animal study to assess the feasibility of a variety of interventional neurovascular procedures under real-time MRI guidance.

Materials and Methods

After obtaining percutaneous vascular access to the femoral artery on the MR table, transfemoral catheterization of the carotid arteries was performed in ten domestic pigs using active MR-tracking catheters and guidewires. Intraarterial contrast enhanced MRA was performed to confirm the catheter position and to study the distal vascular anatomy. Carotid stenting was performed in five animals. The carotid and subclavian arteries were occluded with balloons to create stroke models in five animals and intraarterial thrombolysis was carried out in two animals. Necropsy was performed on all animals to assess for unintended vascular injury.

Results

The carotid arteries were catheterized forty times within minutes after obtaining vascular road maps. Ten nitinol stents were successfully placed into the bilateral carotid arteries in all five animals (Figure 1). The stent positions were confirmed by necropsy and there was no unintended vascular injury. In the separate experiments, all target vessels were occluded successfully with balloons (figure 2). After the carotid artery branches were occluded intentionally with blood clots in two animals, we infused rtPA intraarterially, which resulted in recannulization of these vessels (figure 3).

Conclusion

Carotid stenting, embolization, and thrombolytic procedures were successfully performed in a swine model using active MR-tracking, suggesting that neurovascular intervention may be feasible under real-time MRI guidance.

References

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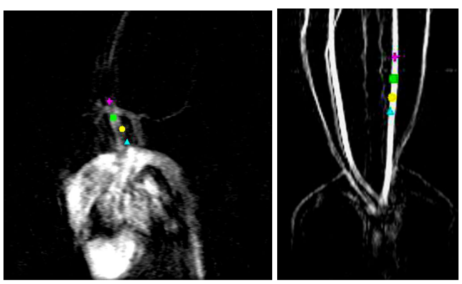

Figure 1. Active-Tracking Catheterization
a. Catheterization of brachiocephalic artery with active-tracking devices. After the guidewire is inserted into the brachiocephalic artery, the catheter is advanced over wire into this artery.
b. Catheterization of the bilateral common carotid arteries with active-tracking devices. The catheter was advanced over wire into the left common carotid artery.

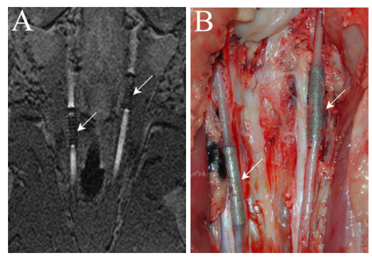

Figure 2. Stents in Bilateral Carotid Arteries
a. Coronal FSPGR image with heavy T1 weighting demonstrates hyperintense blood in bilateral carotid arteries. Stents are identified by susceptibility artifacts of the nitinol struts (arrows). Inferior margin of left stent is intentionally matched with superior edge of right stent.
b. Post mortem dissection of the neck reveals the stents are in the same positions (arrows) as shown on MRI. The stents, which are 8 mm in diameter are not fully expanded because the common carotid arteries are only 5 mm in diameter. Common carotid arteries have shiny adventitia without evidence of perforation or mural hematoma.

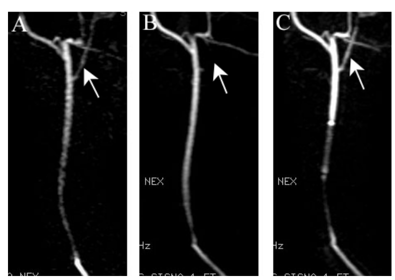

Figure 3. Occlusion and Recanalization with Thrombolysis
a. Intraarterial contrast enhanced MRA of left carotid artery
b. Occlusion of ascending pharyngeal artery (arrow)
c. Recanalization after thrombolysis