Real-time MRI-Guided Recanalization of Chronic Total Arterial Occlusion in Swine

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Introduction: Recanalization of chronic total occlusions (CTOs) is a challenging clinical procedure traditionally conducted under X-ray guidance to improve blood flow to patients with symptomatic ischemia. X-ray guidance generally does not provide imaging or geometric information about the arterial contours[1]. In the absence of this information, devices may inadvertently exit the native/true vascular lumen, leading to perforation and hemorrhage, and making the procedure risky. We have developed an MRI-active and trackable guidecatheter (GC) and a guidewire (GW) system, which can be used to navigate within the walls of the occluded artery. We have successfully tested the feasibility of using this active GW and the GC system to recanalize model CTOs in a porcine carotid artery model using real-time MRI guidance.

Materials and Methods: A 7F MRI-active GC has an inductor loop coil built into the walls in the distal 2.5 cm section. The 2.5F GW is a coaxially arranged nitinol coaxial cable with mechanical properties similar to an interventional wire, and has an inductor loop coil at the distal end. The output of the GC and the GW are matched and tuned using an external interface circuitry. The porcine model of a totally occluded carotid artery was created by mechanical injury to the carotid artery followed by high lipid diet for 4-6 weeks. SAR testing was carried out in an acrylamide gel phantom of 0.7 siemens/m conductivity, local temperature change was measured, and SAR was estimated. The CTO recanalization procedure was carried out on a Siemens Sonata XMR system with customized image reconstruction system [2]. The animal was confirmed for CTO of the carotid artery by x-ray angiography prior to recanalization under MRI guidance (Figure 1A). The animal was then moved to the MRI suite and the occluded artery identified. The active GW and GC were then introduced into the origin of the occluded left carotid artery and were gradually advanced through the length of the occluded artery lumen, in tandem during imaging. This was accomplished using multiplanar image guidance, with selected planes including longitudinal planes along the intended device trajectory and multiple parallel short-axis planes proximal and distal to the guidewire tip. These views showed both the occluded vessel and the location of the interventional devices, and were monitored continuously to maintain the devices within the walls of the occluded vascular lumen (Figure 2) (SSFP: TE=1.8, TR=3.6, FOV=20x30 cm, ST=6 mm, Flip angle=45, NEX=1). The GW and GC were displayed in different colors on the images (red and green, respectively). On complete recanalization of the occluded vessel, the GC was removed and a balloon catheter was introduced over the GW; then, the lesion was dilated to restore normal blood flow, as shown in Figure 1C. This recanalized vessel was confirmed by x-ray angiography, as shown in Figure 1D.

Results: The distal 10 cm of the GW was visible on MRI with the brightest signal at the location of the inductor coil. The distal 2.5 cm of the guidecatheter was visible on MRI. The signal profiles of the GC and the GW were distinct, which enabled differentiation of the two devices. SAR at the distal tip of the catheter and the wire was measured to be less than 4W/kg. Carotid artery CTOs were successfully recanalized in porcine models using MRI guidance. The GC and the GW were visible and could be steered and maintained in the occluded vessel under MRI guidance.

Conclusion: We have demonstrated the feasibility of recanalization of chronic total occlusion of pig carotid arteries using real-time MRI guidance. We believe that this method can be extended to patients suffering from chronic total occlusion of non-coronary arteries

References:

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2. Guttman, M.A., et al., J Cardiovasc Magn Reson, 2002. **4**(4): p. 431-42.

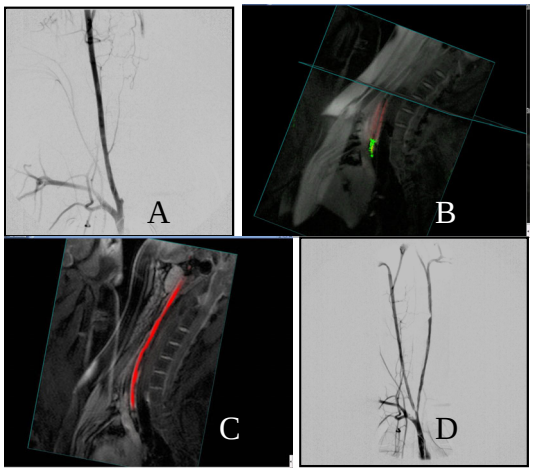

Figure 1: The CTO carotid artery (A) is recanalized (B), and dialated with a balloon catheter (C) to restore normal blood flow. This is confirmed by x-ray angiography (D).

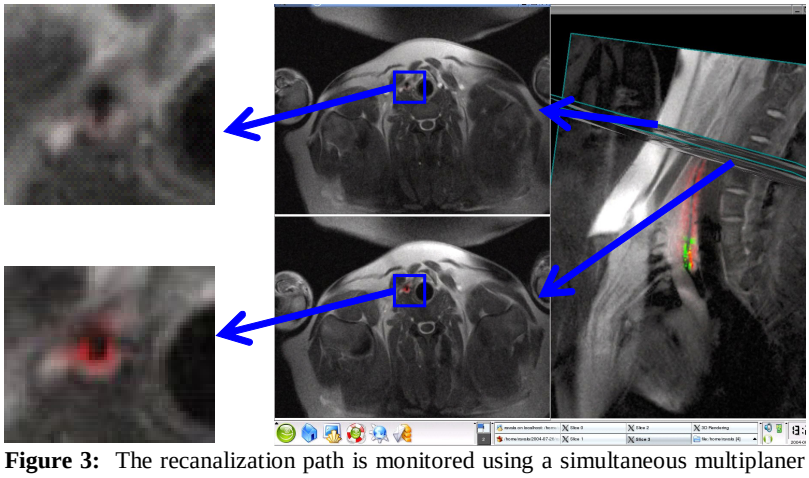

Figure 3: The recanalization path is monitored using a simultaneous multiplaner imaging interface. Multiple axial and sagittal planes are monitored during the recanalization procedure and show the position of the interventional devices in the occluded vessel (guidewire in red and guidecatheter in green).