771

Guidance to the Branching Vessels of the Aortic Arch with Passive MR Catheter Tracking

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Introduction

Endovascular therapy has been demonstrated as an effective surgical technique in the treatment of several vascular diseases, including atherosclerosis, aneurysms, and atrial fibrillation. Catheters are guided through the vascular systems to points of disease, allowing access from the peripheral vessels (*i.e.*, radial or femoral arteries), to regions of the body that are more difficult to access (*i.e.*, the internal vasculature of the heart or brain). In order to guide the endovascular devices imaging is required; most often for clinical applications the preferred modality is x-ray imaging because of the high spatial and temporal resolutions that it provides. MR imaging has been demonstrated for catheter tracking applications, and there are, generally, two approaches when localizing the devices: 1) active tracking, where antenna coils are mounted onto devices, or 2) passive tracking, where material properties are used for localization. Likely as a result of the apparent greater focus on active tracking, this method is attributed with more successful results in the literature. Irrespective of the approach, near areas of motion, such as the thoracic cavity, it becomes difficult to localize devices as motion artifacts can significantly distort the real-time image. Active tracking has been demonstrated at much higher frame rates then passive tracking (> 5 Hz and < 1 Hz, respectively). Visualization of devices using passive catheter tracking has been limited to regions of slower motion. It would be expected that by accelerating passive imaging to rates equivalent to those of active tracking (> 5 Hz) guidance near the aortic arch and the branching vessels could be achieved. This work demonstrates passive MR catheter in areas of motion by tracking in the ascending aorta and the brachiocephalic trunk in a canine model using passive MR catheter tracking methods.

Methods

A 3 T MR scanner (Signa VH/*i*, General Electric Healthcare, Waukesha, WI) was used for these experiments. A real time imaging application was written in C/C++ to run on a reconstruction computer (Mac Mini, Mac OS 10.6, 2 GHz Core 2 Duo, 4 GB of RAM). This computer was interfaced to the scanner using TCP/IP protocol. The MR imaging pulse sequences (bSSFP for the roadmap and SPGR using mcPD for tracking) were accelerated by compressed sensing and modified to port data directly to the real-time imaging application. Ethics approval was obtained. Five animals were anaesthetized and the femoral artery was punctured to allow access for a catheter. A 5 F straight-tipped catheter was filled with 4% (20 mM) contrast agent (Magnevist, Berlex, Pointe-Claire, QC) and inserted into the left femoral artery. The catheter was navigated up the descending aorta and, using accelerated real-time MR imaging, guided into the ascending aorta and brachiocephalic trunk.

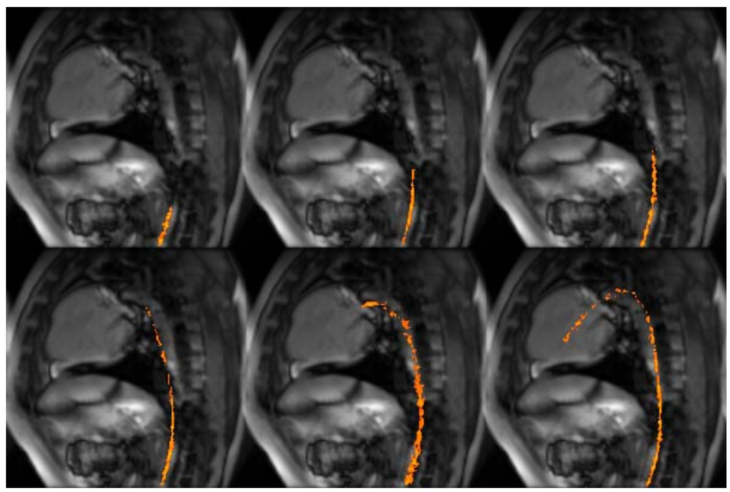

Fig 1: Catheter being guided into the ascending aorta with passive MR imaging. Accelerated imaging allows visualization near heart and lung motion.

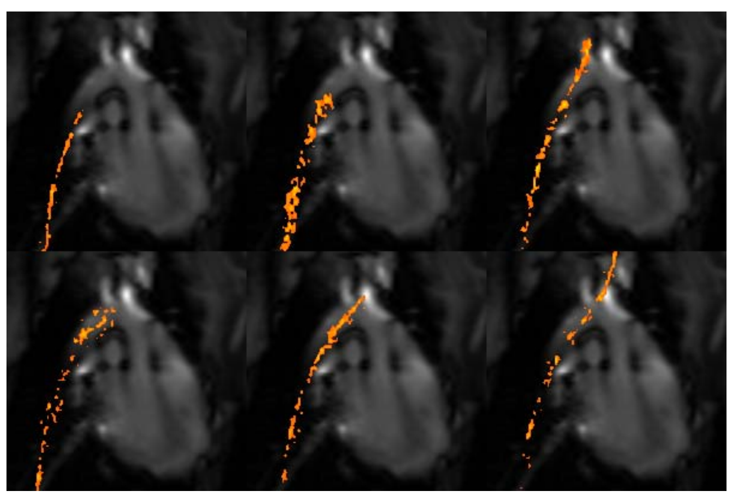

Fig 2: Catheter being guided into the brachiocephalic trunk.

Results

The images were acquired at 5.2 Hz. The catheter was successfully guided into the ascending aorta (Fig 1) and into the brachiocephalic trunk (Fig 2). The device was visualized as it was guided up the descending aorta and is moved up to the ascending aorta. Signal along the catheter was good in the descending aorta, however, near the heart, the signal along the catheter was less continuous but still conspicuous. Further image acceleration resulted in reduced SNR, making it difficult to see the device. bSSFP roadmaps were effective for catheter tracking, particularly in regions of motion.

Conclusions

Passive catheter tracking when combined with accelerated MR imaging can be used to guide catheters into the ascending aorta of a canine. Imaging rates with passive tracking reached rates previously reported for active tracking. Proof of concept for passive catheter tracking near regions of intense motion has been demonstrated. Additional work is required to achieve fast image reconstruction using compressed sensing.

References

1. Quick *et al.*, *Magn Reson Med* , 2003; 49:129-137
2. Draper *et al.*, *Magn Reson Med*, 2006, **24**:160-167