Whole-Heart MR Angiography using Image-Based Navigation in Patients with Congenital Heart Disease

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Introduction: Whole-heart MR angiography (MRA) allows for non-invasive and radiation-free assessment of the heart and great vessel anatomy in patients with congenital heart disease, including the detection of intracardiac shunts and vascular abnormalities[1]. However, respiratory motion remains an impediment in a significant amount of patients undergoing free-breathing MRA[2]. MRA in non-anaesthetized patients is particularly susceptible to respiratory motion artifacts in the event of irregular breathing or respiratory drift. Here, we evaluate a recently developed 2D image-based navigator (iNAV)[3] for whole-heart MRA in non-anaesthetized adult patients and compare it to the gold standard 1D diaphragmatic navigator (1DNAV).

Methods: Experiments were performed on a 1.5T Philips (Philips Healthcare, Best, The Netherlands) clinical scanner using a 32-channel receiver coil. In this prospective study, 28 adult patients with congenital heart disease were enrolled and provided written informed consent. MRA was performed twice for each patient, using 1DNAV with a 6mm gating window and a fixed tracking factor of 0.6, and iNAV[3] with direct motion correction of respiratory heart motion in foot-head and left-right direction and respiratory gating using a bellows signal. The iNAVs were generated by adding phase encoding gradients to the startup echoes[4] and using SENSE and partial Fourier image reconstruction to improve the spatial resolution. The iNAV motion correction was implemented on the scanner computer. The MRA consisted of a fat suppressed and T2prepared whole-heart SSFP protocol with 1.5mm isotropic resolution. The order of the two scans was randomized for each patient. Vessel sharpness of the left anterior descending (LAD) artery was used for quantitative comparison of the methods. A visual score from 0 (uninterpretable) to 4 (excellent) image quality was assigned to each dataset by a blinded expert for qualitative comparison. A significance threshold of $P < 0.05$ was used.

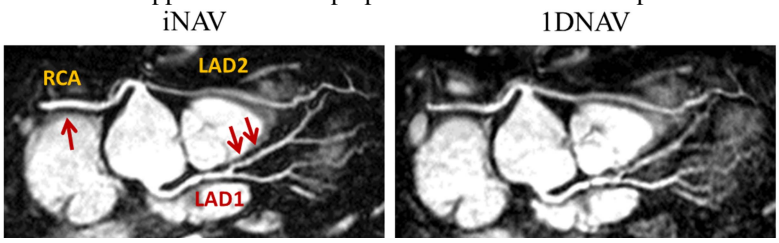

Figure 1. *MRA in 42-year-old patient with a dual LAD. Improved visualization of the primary LAD (LAD1) was obtained with image based navigation (iNAV) compared to the 1D navigator (1DNAV).*

Results: MRA was successfully obtained in all 28 patients using iNAV. However, one scan was aborted using the 1D NAV due to extremely low scan efficiency (<15%). Images from a 42-year-old man with ventricular septal defect are shown in Figure 1, where MRA revealed a type IV dual LAD[4]. Improved visualization of the primary LAD was obtained using iNAV compared to 1DNAV. Representative images from 2 patients, reformatted to show the right coronary artery (RCA) and LAD are shown in Figure 2. Table 1 summarizes the quantitative and qualitative results and statistical comparisons. Statistically significant differences were found for the scan time, vessel sharpness and visual score, favouring the iNAV over 1DNAV.

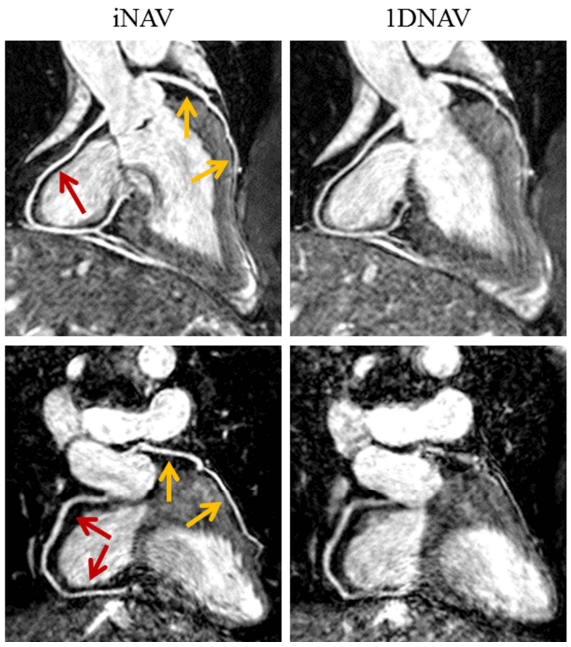

Figure 1. *MRA in two patients with congenital heart disease, reformatted to visualize the RCA and LAD. Improved image quality was obtained using iNAV.*

Discussion and Conclusion: In this work we have demonstrated the usefulness of image-based motion correction for whole-heart MRA to reduce scan time as well as improve the image quality compared to the gold standard MR method.

	1DNAV	iNAV	P
Scan time (sec)	560±180	479±93	0.003
Vessel Sharpness (%)	56.4±8.5	60.9±7.0	0.03
Visual Score	2.3±1.0	3.0±0.8	0.01

References: 1 Tangcharoen, Radiology, 2011; 2 Scott, Radiology, 2009; 3 Henningsson, MRM, 2012