Dual Navigators for Time-Resolved MR Coronary Blood Flow Imaging at 3T During Free Breathing

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Abstract

In native and bypass graft coronary arteries, MR flow measurements can be used to non-invasively assess vessel patency [1]. Because of the small vessel diameter and rapid motion of the coronary arteries, a high spatial and temporal resolution is mandatory. Therefore, navigator-gated scanning is favorable, as the acquisition is not limited to breath-holds, and high spatial and temporal resolution can be achieved [2]. However, navigator pulses need to be applied at the end of the RR interval to access the early systolic flow peak. Thus, the performance may be limited by the time-lag between navigator and image acquisition at the onset of the cardiac cycle. To overcome this shortcoming, an improved dual navigator technique is presented that analyzes navigator information from the current and the preceding cardiac cycle. To achieve high spatial resolution with sufficient SNR, all experiments were performed at high field strengths. Initial in-vivo results are presented to demonstrate the feasibility of the technique.

Methods

The studies were performed on a 3T whole body scanner (Philips Medical Systems, Best, NL). A six-element cardiac phased array was used for signal reception. Time-resolved coronary MR blood-flow images were acquired in 5 healthy adults during free breathing. A trailing navigator was acquired at the end of each cardiac cycle. To cope with the long time-lag between navigator and data acquisition at the beginning of the RR-interval, the navigator information acquired in the preceding cardiac cycle was also analyzed (Fig. 1). Data were only accepted for reconstruction if the detected lung-liver interface positions fell within the same 5mm gating window for both navigators. The following sequence parameters were used: 2D acquisition; slice thickness 10mm, FOV=280mm; resolution measured/reconstructed=(0.76mm)²/(0.55mm)²; V_{ENC}=35cm/s; TR/TE=6.3/3.8ms, FFE with flip angle a=20°; temporal resolution 25ms. For comparison, a conventional protocol using a single trailing navigator was acquired in one case.

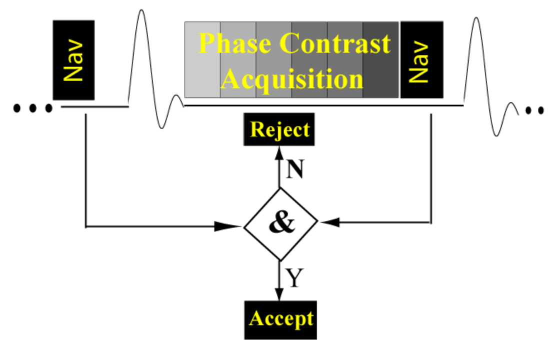

Fig. 1: Respiratory gated acquisition with dual navigators.

Results

Figure 2a/b display example magnitude images obtained with a conventional protocol (a), and with the dual navigator technique (b). A phase contrast image and the measured flow over the cardiac cycle in one volunteer are shown in Fig. 2c/d, respectively. The total scan time (free breathing) was approx. 3,5 minutes for the conventional protocol, and 5 minutes for the dual navigator technique. A high spatial in-plane resolution of 0.76x0.76mm² (reconstructed to 0.55x0.55mm²) on the magnitude and flow images was obtained. Thus, up to 66 voxels across the RCA section were included in the flow measurement as shown in Fig. 2c (dotted circle). The mean values for the measured systolic/diastolic peak flow were 25 cm/s and 15 cm/s, respectively.

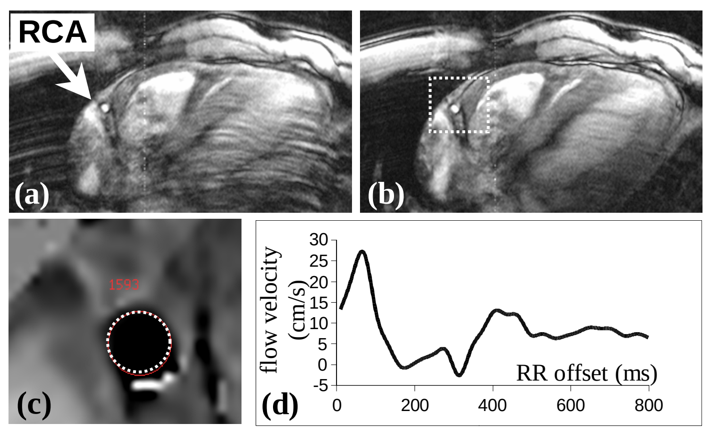

Fig. 2: Magnitude images with conventional navigator gating (a), and with the dual navigator technique (b). Motion artifacts are reduced substantially. A section of the phase contrast map showing the right coronary artery (RCA, cf. dotted ROI in 2b) and the measured flow over the cardiac cycle are shown in (c) and (d), respectively.

Discussion and Conclusion

Using the proposed dual navigator technique, a sharp delineation of the RCA was achieved in all volunteers during free breathing. Despite long delays between navigators and data acquisition, a good suppression of respiratory motion at the expense of an average increase of 40% in scan time was obtained with the dual navigators. A very high spatial resolution was achieved, and the large number of voxels across the RCA section (cf. Fig. 2c) reduces partial volume effects for measuring the flow-velocity map significantly. Due to the inflow of fresh, unsaturated magnetization into the imaging plane, the full benefits of increased polarization at 3T are realized. A high temporal resolution of 25ms was obtained, and access to early systolic flow is enabled. Future studies are necessary to validate this method in patients.

References:

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