Real-Time Phase-Contrast Flow Imaging with Low-Rank Modeling

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Target audience:

Scientists interested in real-time phase contrast flow imaging

Purpose:

Phase-contrast (PC) MRI is a powerful tool for quantitative assessment of blood flow dynamics, and has been widely used in clinical practice [1, 2]. The conventional approach is based on electro-cardiogram (ECG)-synchronized cine acquisitions, which often suffers from relatively low acquisition efficiency, and is not well suited to assessing hemodynamic variabilities (e.g., in cardiac arrhythmias). Real-time flow imaging is a promising direction to overcome these limitations [3, 4]. Recently, we have developed a novel real-time PC-MRI method based on low-rank modeling [5-8]. In this abstract, we illustrate its performance with examples from in vivo experiments (on both healthy and pathological human subjects).

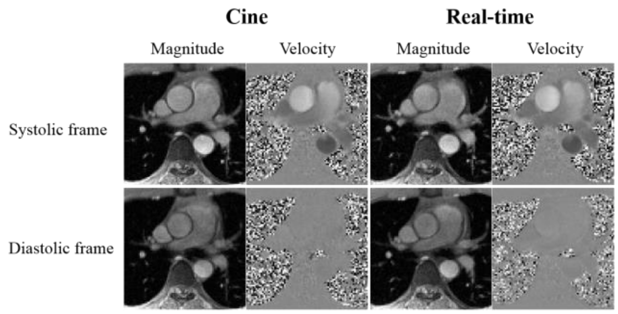

Fig. 1 The magnitude images and velocity maps corresponding to systolic and diastolic cardiac phases from the conventional cine method and the proposed method for a healthy subject.

Methods:

The experiments were performed on a 3.0 T Philips scanner with a 32-channel cardiovascular coil. We performed both the conventional cine flow MRI with retrospective ECG gating and the proposed real-time flow imaging method with no ECG gating. In our study, a healthy volunteer (male, 26-year old) and a patient with sinus arrhythmia (male, 23-year old) were recruited. The cine and real-time flow experiments were conducted on imaging planes perpendicular to ascending aortas and descending aortas during free breathing, and with the velocity encoding along foot-to-head direction. For the cine acquisition, the ECG gating was set according to the estimates of subjects' heart beat periods, and three averages were performed to mitigate respiratory motion artifacts. For both experiments, the following imaging parameters were used: field of view = 240 mm × 225 mm, matrix size = 132 × 124, spatial resolution = 1.80 mm × 1.80 mm, slice thickness = 5 mm, repetition time/echo time = 4.5/2.8 ms, flip angle = 10°, and encoding velocity = 200 cm/s. For the real-time flow imaging, the temporal resolution is 18 ms, while for the cine imaging, the temporal resolution is around 36 ms (with 28 cardiac phases). The total acquisition time for both experiments were around 94 s.

Results and Discussion:

Figure 1 shows the results from the cine imaging method and the proposed method for a healthy subject. As can be seen, the proposed method reconstructs magnitude images and velocity maps that have similar quality to that from the cine acquisition. Figure 2 shows the results for the patient with cardiac arrhythmia. Additionally, we show the ECG signal recorded during acquisitions. As can be seen, the flow profiles reconstructed from the proposed method clearly resolve the abnormality of cardiac motion for arrhythmic patients. Such abnormality can also be seen from the reconstructed spatial images and velocity maps. Moreover, note that the variations of the flow velocities for the ascending and descending aorta well correlate with the ECG signal.

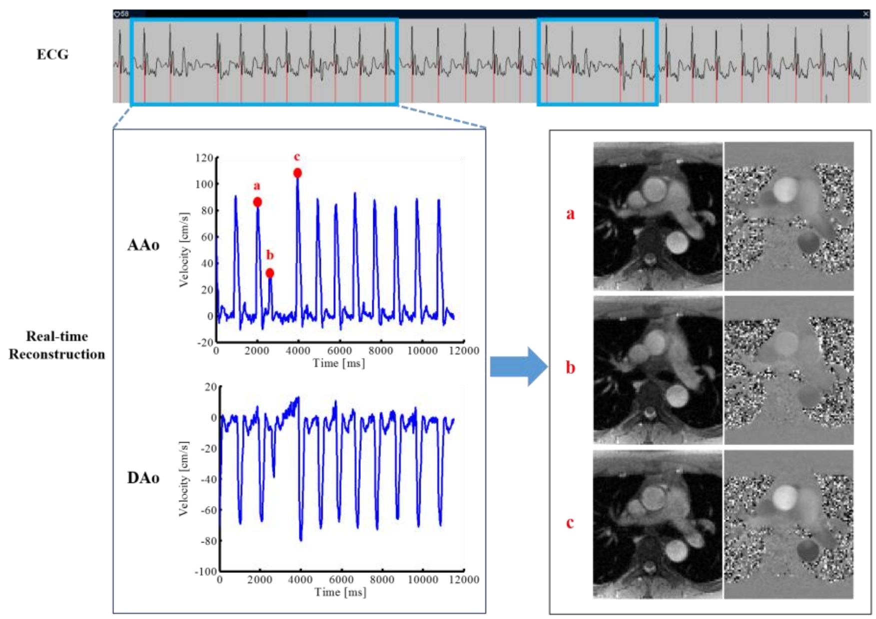

Fig. 2 Results for the arrhythmic patient from the proposed real-time imaging method: the ECG recordings (Top); flow profiles of ascending aorta (AAo) and descending aorta (DAo) (Bottom Left); magnitude images and velocity maps for the three representative time frames during the arrhythmia period (Bottom right).

Conclusions:

In this work, we have illustrated the effectiveness of the proposed real-time PC-MRI method with in vivo experiments. For the healthy subject, we have observed excellent correlation between the conventional cine method and the proposed method, which is highly desirable. For the arrhythmic patient, the proposed method provides new information on beat-by-beat flow variations, which cannot be obtained by the conventional cine based method.

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References:

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