IMPORTANCE OF HIGH TEMPORAL RESOLUTION IN PEAK FLOW VELOCITY QUANTIFICATION BY PHASE-CONTRAST IMAGING

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Introduction Phase-contrast (PC) magnetic resonance imaging is a promising tool for quantification of flow peak velocity, which is clinically significant in diagnosis of valvular diseases and congenital defects. Inconsistency between MR and echo measurements in quantifying flow in valvular diseases has been reported[1]. Turbulence induced signal loss due to finite TE in classic flow quantification sequence was found to be one contributing factor[2] but that does not account for inconsistency found in cases with mild or moderate regurgitation where flow is unlikely to be turbulent. In this study, we looked into the effect of temporal resolution on peak velocities measured by PC MRI in healthy volunteers where flow is non-turbulent with the help of an EPI-based flow sequence.

Method The IRB approved study scanned six healthy volunteers (age 26±3, 5 males and 1 female) using a 3T scanner (TIM TRIO, Siemens, Germany). Through-plane velocity was measured in each volunteer in the ascending aorta immediately distal to the aortic valve leaflet tips. The comparison include: (1) **protocol A**, prospective triggered FLASH-based PC sequence; (2) **protocol B**, same as protocol A but supported view sharing; (3) **protocol C**, retrogated FLASH-based PC sequence and (4) **protocol D**, the EPI-based flow imaging sequence. Its high acquisition speed improves temporal resolution. Common imaging parameters were: FOV=360×270mm^2, slice thickness=8mm, matrix size=192×144, flip angle=15◦, VENC=170cm/s. GRAPPA rate 2 and TE=1.9ms were used for **protocols A-C**. TGRAPPA rate 3, 9 echoes, TE=2.1ms and 3 averages (to improve SNR) were used for **protocol D**. Each protocol took about 15 seconds and breath-hold was needed. Table 1 shows the achieved temporal resolution of these protocols. A MATLAB program was developed to find the peak velocity and the probability distribution function (PDF) of the velocities of blood flowing through the valve.

Results Time varied peak velocity plot of a representative volunteer was shown in Fig. 1. Velocities measured from the EPI-based sequence (**protocol D**) were higher than the other three protocols, especially at around end-systole (ES) when the velocity reached maximum. Velocity maps of the volunteer at the time point when maximal velocity presented were displayed in Fig. 2. Correspondingly, the normalized velocity PDFs of blood flowing through the valve were shown in Fig. 3. The EPI sequence contained more pixels with higher velocities than the other techniques despite the effect of averaging. Similar results were observed for the remaining volunteers. The maximal peak velocities averaged from the 6 subjects were summarized in Table 1, and the peak velocities attained from the EPI-based method were the highest.

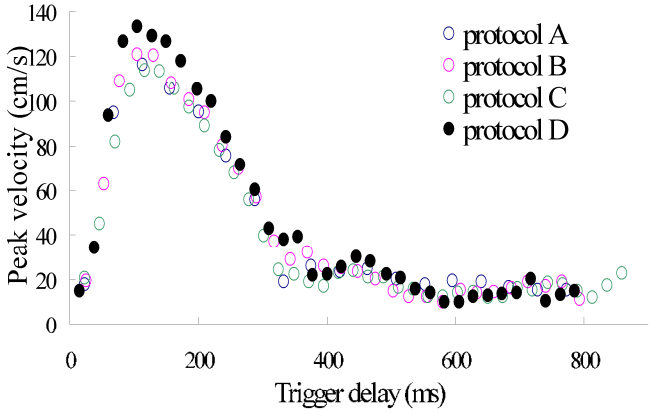

Fig 1 Time varied peak velocity during a cardiac cycle.

Discussion and conclusion

In this study, each flow imaging scan was repeated three times, and the results were consistent, demonstrating reproducibility of the protocols. Peak velocities measured from the high temporal resolution EPI-based method (with 3 averages to reduce noise) was found to be higher than the other three approaches, suggesting the crucial role of high temporal resolution on quantifying peak flow even in healthy subjects. The results also demonstrated that higher apparent temporal resolution (through retrospective gating or echo sharing) showed little improvement on capturing peak velocity, most likely because these post-processing techniques only interpolated existing data. The experiments suggested that the temporal resolution from standard PC techniques needs to be used with care as the true temporal resolution may be marginal in peak flow quantification. A high temporal resolution would substantially improve the fidelity of peak velocity measurement, especially in characterizing stenotic valves. Clinical relevance of the proposed method will need to be evaluated in patients with valvular diseases.

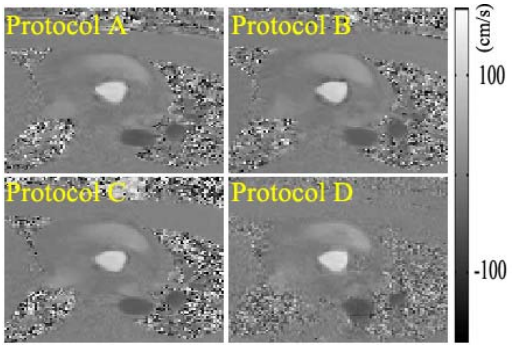

Fig 2 Peak velocity maps at ES.

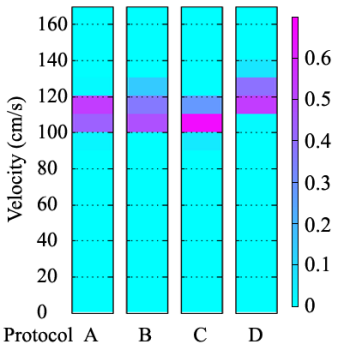

Fig 3 Normalized velocity PDFs at ES.

Table 1 Temporal resolutions and maximal peak velocities of the four protocols.

	Protocol A	Protocol B	Protocol C	Protocol D
True temporal resolution	43.8 ms	--	43.8 ms	22.6 ms
Apparent temporal resolution	--	26.4 ms	22.7 ms	--
Maximal peak velocity (cm/s)	130.6±16.3	128.2±13.2	131.7±12.5	141.6±16.9

References [1] Gelfand EV et al., JCMR 2006; [2] O'Brien KR et al., MRM, 2009

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