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Sensitivity of 3D phase contrast MRI flow measurements to background phase correction

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BACKGROUND: The usual method of vascular flow measurements is 2D phase contrast MRI (2DPC). However, 3DPC, is an attractive alternative in some scenarios thanks to benefits, such as retrospective interrogation.

PURPOSE: This study examines the sensitivity of clinical flow measurements to variations in static tissue definition and polynomial fitting for the process of background phase correction in 3DPC MRI.

METHODS: In 31 patients presenting for routine CMR, four 2DPC and a single 3DPC MRI acquisition were made covering the ascending aorta, main, left and right pulmonary arteries. Scans were performed on a 1.5 T GE Discovery MR450 scanner. Flow measurements from 2DPC data were made following background phase correction using repeated scans of static gel phantoms.

Static tissue was manually defined for each subject and flow measurements were made from 3DPC datasets following a variety of background phase corrections that represented the use of different polynomial fits (linear to 4th order) and variation in the quantity and spatial distribution of static tissue used for polynomial definition. In total, 172 different flow measurements were made at each vessel for each subject.

2DPC was used as a gold standard to define the accuracy of 3DPC flow measurements relative to the order of polynomial fit, while variation in static tissue was then applied to investigate sensitivity.

RESULTS: The accuracy of 3DPC flow measurements compared with 2DPC data was very good with a mean range between flow measurements using a linear to 4th order fit less than 5 mL or 8% per cardiac cycle. There were no significant differences between flow results from different orders of fit.

Linear polynomial fitting was largely insensitive to subsampling of the static tissue points, so long as they remained evenly distributed about the volume: for static tissue subsampled at 1-99% of total, variation of flow measurements was <1%. Higher degrees of polynomial fitting were insensitive to evenly distributed subsampling only if the portion of static tissue used was greater than 25%, below which the error grew exponentially.

Unevenly distributed subsampling of the static tissue resulted in large variation of flow measurements. Using only a cluster of static tissue points from one half to one eighth of the domain resulted in median changes to flow measurements of 5% for a linear fit while higher order fits experienced an increase in flow measurement errors proportional to the degree of polynomial fit (Fig.1).

CONCLUSIONS: Background phase correction based on static tissue fitting in 3DPC can be accomplished with low order polynomial fitting, which is more robust to the choice and distribution of static tissue points.

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