Journal of Cardiovascular Magnetic Resonance

Poster presentation

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Inline directionally independent magnitude of velocity maps calculated from 3D encoded phase contrast images

Christopher Glielmi*[1], Jie Deng[2], R Andrew deFreitas[2], Cynthia Rigsby[2], Sven Zuehlsdorff[1] and Peter Weale[1]

Address: [1]Siemens Healthcare, Chicago, IL, USA and [2]Children's Memorial Hospital, Chicago, IL, USA
* Corresponding author

from 13th Annual SCMR Scientific Sessions
Phoenix, AZ, USA. 21-24 January 2010

Published: 21 January 2010

Journal of Cardiovascular Magnetic Resonance 2010, **12**(Suppl 1):P242 doi:10.1186/1532-429X-12-S1-P242

This abstract is available from: http://jcmr-online.com/content/12/S1/P242

Introduction

Phase contrast magnetic resonance (MR) with velocity-encoding provides cardiovascular flow visualization and quantification of the severity of stenosis by evaluating the peak velocity within the core of a post-stenotic jet. MR typically underestimates peak velocity due in part to reliance on a through-plane velocity-encoded 2D slice orientated perpendicular to the jet. However, post-stenotic jets frequently exhibit a degree of eccentricity and can change direction throughout the cardiac cycle. Current methods rely on optimal slice orientation [1,2].

Purpose

We propose inline computation of velocity magnitude independent of direction, eliminating reliance on optimal slice orientation and facilitating clinical evaluation of irregular flow patterns as found in stenotic jets.

Methods

Imaging

5 patients (4 females: 6-22, 1 male: 10) with congenital heart disease and 2 healthy volunteers (male: 34 years, female: 27 years) were scanned on Siemens 1.5 T scanners (Avanto and Espree, Siemens Healthcare, Erlangen, Germany). Data were acquired using a phase contrast sequence with 3 flow encoding directions and one flow compensated reference (TR/TE = 26/3.4 ms, 1.3 × 1.3 × 5.0 mm resolution, VENC 100-200 cm/s).

Processing

Phase differences between each flow encoded and the flow compensated images were quantified in terms of velocity for each direction. Next, the root sum square of 3 directional velocities yielded pixel-wise magnitude of velocity independent of direction. All processing was programmed in the Siemens Image Calculation Environment (ICE) enabling immediate visualization and evaluation of results.

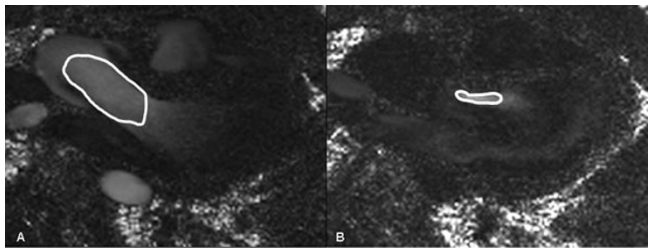

Figure 1
Magnitude of velocity images show peak velocityin aortic root in systole (A) and regurgitant jet during diastole (B). Accurate assessment of the magnitude of the velocites can be made independent of flow direction. In this case, the regurgitatn jet peak velocity matched the single direction evaluation but the aortic root was significantly different as the in-plane flow encoding direction was not perfectly aligned with bulk flow direction.

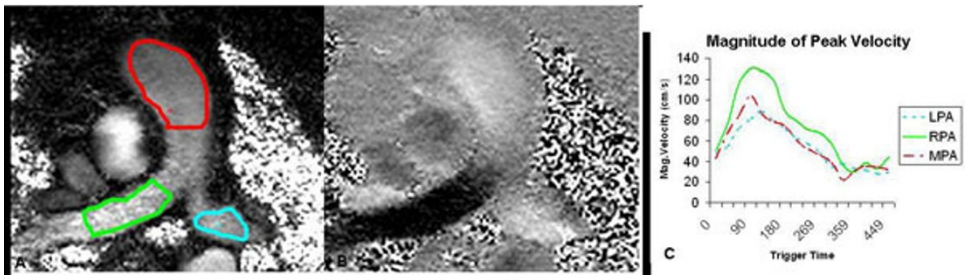

Figure 2
Single scan depicting the pulmonary trunk and proximal right and left pulmonary arteries. Accurate assessment of peak velocity was possible in the MPA and both branches in from a single image. MPA velocity was verified by conventiaional through plane flow quantification (88 cm/s vs. 83.5 cm/s).

Results

Figure 1, In patient studies the peak velocities measured in systole for all patients and diastole where regurgitant jets were present demonstrated a 9% average increase over single direction measurements. In cases where the flow direction was appropriately orientated, little benefit was seen with the magnitude of velocity calculation. However, in cases of turbulent flow, eccentric jets or poor slice placement, more significant differences were observed up to 32%. Healthy volunteer studies further demonstrate the feasibility of assessment of peak velocities in multi-directional, branching vessels which can be measured in a single scan using this method (Figure 2).

Conclusion

Magnitude of velocity calculation provides a more accurate peak velocity measurement that is independent of slice orientation, flow direction and temporally variable jet direction. Inline computation of magnitude of velocity provides immediate visualization and integration with conventional post-processing tools. Limitations include longer TE than single direction acquisitions and intravoxel dephasing of in-plane sensitivity.

References

1. Lotz , *et al.*: *RadioGraphics* 2002, **22:**651-671.
2. Zhao , *et al.*: *MRM* 2000, **18:**697-706.