Journal of Cardiovascular Magnetic Resonance

BioMed Central

Moderated poster presentation

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Whole chest MRA and velocimetry for congenital heart disease in less than 10 minutes with 3D radial phase contrast

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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):M3 doi:10.1186/1532-429X-12-S1-M3

This abstract is available from: http://jcmr-online.com/content/12/S1/M3

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Introduction

MRI of congenital heart disease (CHD) usually requires acquisition of multiple anatomical and functional scans followed by several 2D phase contrast (PC) acquisitions in various scan planes for flow measurements. A 3D PC technique using vastly undersampled isotropic projection reconstruction (PCVIPR) with respiratory gating allows for volumetric 3D flow imaging with high spatial and temporal resolution over a large field of view in less than ten minutes during free breathing. Previously shown to be accurate for renal MRA and quanitification of pressure gradients, we have recently extended this technique to thoracic MRA (Figure 1).

Purpose

Develop rapid 3D PC technique for comprehensive cardiovascular imaging in CHD.

Materials and methods

PCVIPR data were acquired after obtaining informed consent according to our IRB protocol in 10 normal volunteers and 43 patients with CHD. Patients had a variety of pathology including aortic coarctation (13, Figure 2), bicuspid aortic valve (8), tetralogy of Fallot (8), atrial septal defect (7), partial anomalous pulmonary venous return (4, Figure 3), ventricular septal defect (3), and single ventricle (3). PC VIPR datasets were reconstructed as magnitude images for anatomical assessment. To reliably achieve high quality images, several correction schemes were applied to account for the effects of T1-saturation, trajectory errors, motion, and aliasing associated with undersampling. Typical scan parameters were: 62.5 kHz receiver bandwidth, 1.0-1.25 mm isotropic spatial resolution in less than 10 minutes with 50% respiratory gating efficiency, imaging volume: 32 × 32 × 16 cm, VENC of 50-100 cm/s (application specific). Cardiac gating was performed retrospectively with a temporal filter for radial acquisitions. CE-MRA and 2D PC images were used for comparisons when available. Data processing in customized analysis and visualization tools (Matlab and Ensight).

Results

PCVIPR data sets were successfully acquired in all subjects. MR angiograms were created using the average flow PCVIPR dataset to visualize cardiovascular structures. All anatomical structures visualized on CEMRA images were identified on PCVIPR images. On a case-by-case basis, additional hemodynamic information was obtained including visualization of flow patterns, flow quantification, and transstenotic pressure gradients. PCVIPR flow measurements were more accurate than the clinical routine targeted 2D PC measurements.

Conclusion

3D radially undersampled PC MRI has been shown to be a reliable and versatile tool for imaging patients with CHD. Combining shorter scan times and free breathing acquisition should make cardiac MRI a safer and more patient friendly examination in patients with CHD.

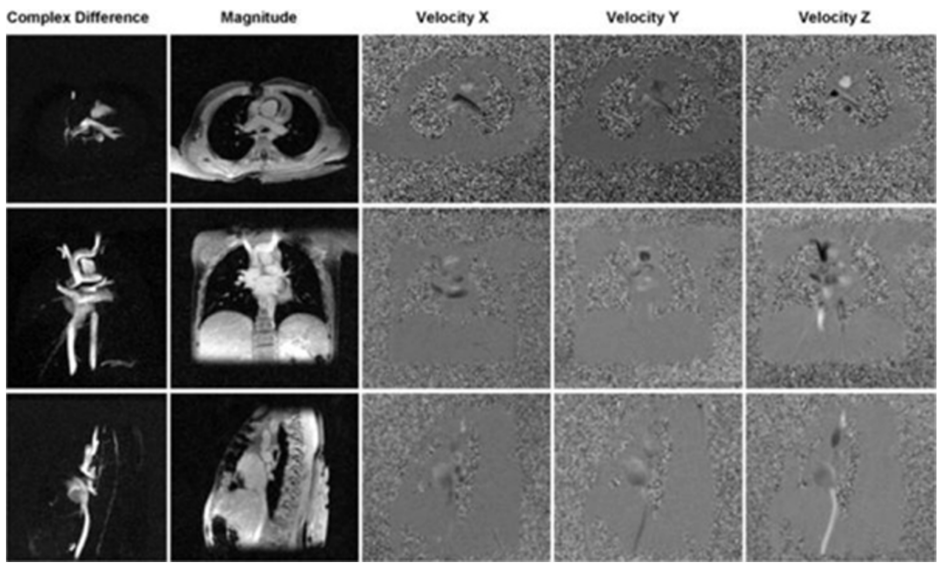

Figure 1

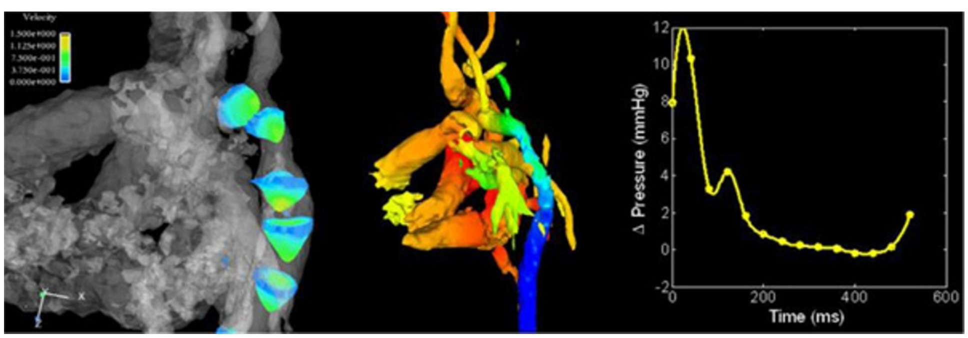

Figure 2

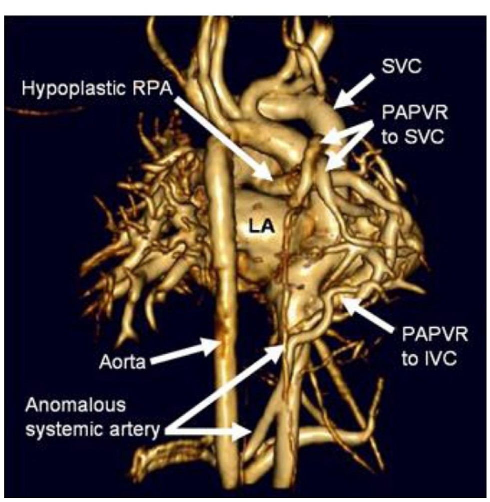

Figure 3