FUNCTIONAL IMAGING IN CONGENITAL HEART DISEASE WITH 3D CINE PHASE CONTRAST MRI

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Abstract

Volumetric, time-resolved, phase contrast Magnetic Resonance Imaging (MRI) with three-directional velocity encoding (4D PC MRI) can provide both anatomical and hemodynamic information with high spatial resolution in clinically feasible scan times. This work focuses on the application of 4D PC MRI to congenital heart disease (CHD). Major and minor CHD defects occur in approximately nine defects per 1000 live births, of which about a quarter would be expected to require invasive treatment or result in death within the first year of life. Imaging modalities such as Doppler Ultrasound and CT have been used extensively in CHD patients. Despite several appealing properties, MRI use has

been limited clinically because current protocols for CHD are lengthy and require the use of sedation or general anesthesia in younger or uncooperative patients. Recent advances in MR hardware and data acquisition and reconstruction methodology have facilitated 4D PC MRI which can be used for comprehensive velocity and flow measurements, as well as the derivation of additional hemodynamic parameters such a trans-stenotic pressure gradients and wall shear stress. Therefore, 4D PC MRI could prove extremely useful for CHD diagnosis, surgery planning, and long-term monitoring. Our research focuses on improving the acquisition, reconstruction, and post-processing of 4D PC MRI for clinical use. We were able to extend the velocity range of 4D PC MRI while maintaining a high velocity-to-noise ration in order to optimize the acquisition for regions such as the thoracic vasculature with a wide range of flow velocities. Other aspects of this work focuses on improving the measurement of trans-stenotic pressure gradients. An in vitro study was conducted to validate 4D PC MRI pressure measurements in a stenotic phantom against computational fluid dynamics (CFD) and pressure probe measurements. We have also performed a feasibility study that demonstrates the utility of 4D PC MRI for quantifying vessel anatomy and 4D pressure gradients in both the aorta and pulmonary arteries.