PhD2

BIOQIC

Compressed sensing MRI for 4D-cardiac flow quantification

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Application Area: Cardiovascular **Modality:** MRI **Related:** PhD 1,6,10,14

Background

4D-flow MRI is of growing interest in different fields of cardiovascular medicine, providing many new insights into hemodynamics, for example in the ascending aorta in subjects with bicuspid aortic valve disease or in the left ventricle in subjects with dilated[1-3]. However, 4D-flow MRI still suffers from limited temporal and spatial resolution, long image acquisition times and time-consuming postprocessing.

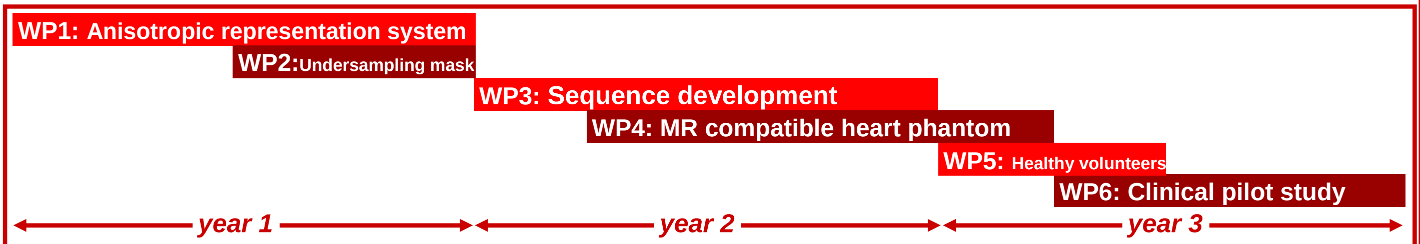
Hypothesis

Quantification of shearlet-based compressed sensing (CS)[4-5] 4D-flow MRI allows fast and reliable assessment of intracardiac flow in patients with outflow tract stenosis at different levels.

Methods

A shearlet-CS-based 4D-flow phase-contrast MRI sequence will be developed and tested on a 3T clinical MRI platform. A pulsatile phantom will be developed to simulate the effects of stenotic disorders on intracardiac flow patterns. The new 4D-flow MRI technique will be validated in several steps including phantom experiments and in vivo applications. Accuracy and reproducibility will be assessed in healthy volunteers. A clinical pilot study will include patients.

Work Packages



WP1: Development of an anisotropic representation system specifically tailored to 4D-flow MRI by, in particular, using structured dictionary learning techniques.

WP2: Establishing an undersampling mask for data acquisition based on incoherence properties.

WP3: Development of a 4D phase-contrast MRI sequence for flow quantification.

WP4: Phantom simulating left ventricular obstruction

WP5: Feasibility trial 20 healthy volunteers to test imaging and postprocessing procedures and to create reference values

WP6: Pilot study in 20 hypertrophic cardiomyopathy (HCM) patients with left ventricular outflow tract obstruction

Clinical Translation

Once established in pilot studies, shearlet-CS-based 4D-flow MRI will be used in long-term trials of patients to improve our understanding of the interaction between vessel and myocardial injury in vascular and valvular diseases.

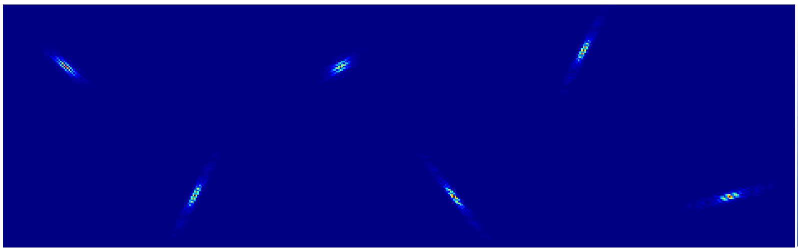


Figure 1. Supports of different shearlets. The shearlet atoms are strongly anisotropic and have different directions due to the shear operation. This allows for an optimal treatment of elongated shapes such as curves. In fact, shearlet systems provably outperform isotropic systems such as wavelets.

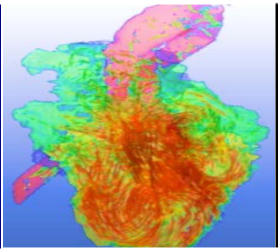


Figure 2. Intraventricular flow (from Deutsches Herzzentrum Berlin, T. Kühne)

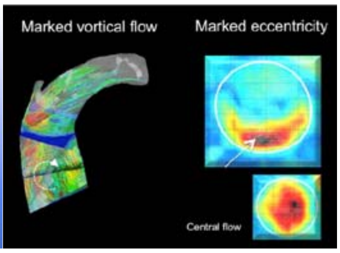


Figure 3 4D-flow patterns in the aorta ascendens, from[6].

Literature

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6. Knobelsdorff-Brenkenhoff, Karunaharamoorthy, Trauzeddel, Barker, Blaszczyk, Markl, Schulz-Menger (2016) Circ Cardiovasc Imag. 9:e004038.