Heart Disease is the #1 killer in the United States, and is responsible for half million deaths and medical costs on the order of $165 billion per year. There are many different types of heart disease (ischemic, valvular, congenital, etc.). Our lab is primarily concerned with ischemic heart disease (IHD) which is caused by a narrowing of the coronary arteries which deliver oxygen and nutrients to cardiac muscle (myocardium). IHD leads to heart attack, and heart failure. We aim to detect IHD in its earliest stages, using magnetic resonance imaging (MRI) of the coronary arteries and blood delivery to the myocardium.

**Myocardial Perfusion Imaging**

Myocardial Perfusion Imaging (MPI) is the imaging of blood flow to the heart muscle. This directly reflects the rate at which oxygen and nutrients are delivered and the rate at which waste products are removed. This is also the single most direct way to assess the physiological significance of ischemic heart disease. Our group is working on two approaches, one that avoids the visual appearance of a dark rim (red arrows in Fig 1), which may lead to an incorrect diagnosis of sub-endocardial disease, and is the single most direct way to assess the physiological significance of ischemic heart disease. Our group is working on two approaches, one that avoids the visual appearance of a dark rim (red arrows in Fig 1), which may lead to an incorrect diagnosis of sub-endocardial disease, and is one of major limitations of first-pass MPI due to its similarity to real perfusion defects.

**Perfusion Imaging using Contrast Agents**

When injected intravenously, the contrast agent mixes with blood and passes through right ventricle (RV), lung, left ventricle (LV), coronary arteries, and then myocardium. The passage of the agent is tracked using a special imaging sequence for 20-30 seconds. Fig. 1 shows representative perfusion images at three selected time points, and corresponding signal changes in LV blood and myocardial segments.

Our group has developed 3D perfusion imaging techniques, that allow assessment of the entire heart muscle. We are developing novel methods that avoid the visual appearance of a dark rim (red arrows in Fig 1), which may lead to an incorrect diagnosis of sub-endocardial disease, and is the primary obstacle preventing widespread clinical use of the technique. Sources of this artifact include Gibbs’ ringing, cardiac motion, and illusion created by the human visual system.

**Vasomotor Function**

Coronary artery dysfunction is one of the earliest measurable elements in the development of IHD. Coronary artery narrowing can be observed directly by viewing the vessel lumen in cross-sectional images. Measuring the subtle vessel dilation in response to stimuli such as exercise may reveal vasomotor dysfunction, a harbinger of IHD. The mid and distal coronary vessels are typically a few millimeters in diameter or smaller, necessitating high spatial resolution.

Our group is developing a new protocol to acquire cross-sectional images along a vessel, with sub-millimeter resolution and SNR sufficient for robust dilation detection. Figure 4 shows preliminary study about detecting a change in lumen area, which demonstrates the need for high SNR for robust detection of small dilation. We are also exploring the feasibility of simultaneously quantifying blood flow through the vessel by phase contrast flow imaging.

For more information, or to learn how you can get involved... Visit: http://mrel.usc.edu
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