Recent Innovations in Cardiac *MR* Course: The Evaluation of Cardiac Function - Unmet Needs

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Highlights

- Cardiovascular Magnetic Resonance (CMR) offers unique opportunities to measure cardiac function that is superior to many competing modalities, but extensive post-processing with user intervention has hindered the clinical adoption of these techniques.
- MR scanners are still primarily geared toward neurological applications, which results in long image acquisition times. Thus, the future of CMR will depend on the ability to provide functional parameters in almost real-time during a shortened examination time to be clinically competitive with other imaging modalities.

Target audience: Basic scientists, Clinicians, Clinician-Scientists, Technologists

Objectives: To understand the strengths and weaknesses of Cardiac MR (CMR) functional evaluation techniques and areas where CMR can be targeted to provide clinically relevant data.

PURPOSE: The purpose of this lecture will be to track the techniques that have been developed for cardiac evaluation of function and determine the hurdles to clinical translation and where these techniques fall short.

DISCUSSION: From the very first images of the heart in the 1970s, there were clear advantages to magnetic resonance imaging over other imaging techniques including computed tomography, angiography, and echocardiography including enhanced detail of the myocardium, the lack of ionizing radiation, non-invasiveness, and true tomographic imaging. In the 1980s methods were developed to track myocardium in the heart, e.g., phase contrast[1] and tagging techniques[2], that offered a unique ability to track segmental motion rather than endocardial and epicardial borders and derive parameters, such as tissue strain, velocity, and strain rates. Phase contrast techniques were also applied to measuring flow within vessels. The development of gadolinium-based contrast agents also offered a method to determine alterations in tissue perfusion. While many early techniques were based on CT iodinated contrast perfusion methods, the lack of ability to directly image MR contrast agents has proved to be a hindrance in rapid determination of semi-quantitative perfusion parameters. Similarly, analysis of these functional parameters in the heart has historically required post-processing of the images with user intervention and semi-automatic analysis tools. Thus, the ability to provide rapid reporting of functional results remains a major hurdling block to acceptance of these techniques.

More rapid imaging techniques, such as steady-state free precession and parallel imaging, and advanced imaging processing techniques that allow the motion of the heart to be frozen without ECG or respiratory gating will enable the rapid acquisition of images in critically ill patients akin to cardiac CT. Newer techniques that allow rapid analysis, such as feature tracking (FT) MRI, or real-time visualization of cardiac regional function, such as strain-encoded (SENC) MRI,[3] will also enhance acceptance of these techniques. Surprisingly, the most advanced analysis packages are generally not provided by the particular scanner vendors, but can be found with private companies. The latter model somewhat enhances cross-vendor platform analysis of studies.

While ideally MRI scanners would be designed specifically for cardiovascular patients, the current trend towards short-bore systems allows better patient access and the ability to perform scans in cardiovascular patients with high BMIs. Further enhancements to scan planning to allow continuous real-time scan plane acquisition or development of 3D acquisitions will speed the ability to get conventional cardiovascular scan planes, i.e., short- and long-axis, or allow reformatting to these scan planes.

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