

David E. Sosnovik

Session: Myocardial Tissue Characterization: (Sunday April 21 - Cardiovascular Educational)

Talk: Myocardial Tissue Characterization: What do we want to see? (Sunday April 21, 11:20)

This syllabus is aimed at the physicists and engineers in the audience who will hopefully benefit from the insights provided.

The evaluation of the heart clinically is predominantly based on its global function. Heart failure for instance is defined as occurring with either reduced or preserved ejection fraction. (These syndromes are often referred to as systolic or diastolic dysfunction, which is not completely accurate since systolic dysfunction is a prominent cause of diastolic dysfunction). The assessment of EF, which is often the first decision point in clinical practice is usually answered by echocardiography. Secondary questions then arise – is the reduced ejection fraction due to coronary artery disease (ischemic) or is it non-ischemic. This is first addressed by assessing myocardial perfusion, either directly by SPECT, PET and Gd-enhanced MRI or indirectly by assessing wall motion using stress echo or MRI.

Stress tests can be based on the use of a coronary vasodilator (e.g adenosine) a positive chronotrope such as dobutamine or on exercise. Exercise provides extremely useful prognostic information independent of the imaging and ECG response to stress. A patient who develops angina during the first 6 minutes of exercise and/or a drop in blood pressure is extremely likely to have multivessel coronary artery disease. These patients usually proceed to invasive angiography regardless of what the imaging shows. At the other end of the spectrum if a patient can complete more than 10 minutes of a standard exercise stress test without symptoms then their prognosis is generally good, regardless of what the imaging shows. So take home point 1: An exercise stress test provides extremely valuable prognostic information and is always preferable if no contraindication exists: Hence techniques for exercise stress MRI must continue to be developed. The preliminary experience from several sites is extremely encouraging.

A high risk stress test will move a patient towards invasive angiography of the coronary arteries. If severe blockages are found the question often arises as to whether the myocardium distal to these blockages is viable (alive). MRI has a crucial role to play here by assessing the distribution of viable and non-viable myocardium. Late Gd enhancement (LGE) is frequently used for this but many patients who require it cannot receive Gd because of coexisting renal dysfunction. This is quite common in patients with cardiovascular disease since the risk factors (e.g. diabetes, hypertension) are the same. Take home point 2 – Techniques to assess myocardial viability based on endogenous contrast are sorely needed. Emerging candidates include magnetization transfer, chemical exchange saturation transfer or CEST, and diffusion tensor MRI. An update on these approaches exploiting endogenous contrast will be provided in the session.

The same limitation of giving Gd to those with renal dysfunction applies equally in perfusion imaging (whether exercise or pharmacological). Ongoing development of techniques exploiting endogenous contrast mechanisms is thus vital. These include BOLD and arterial spin labeling. Take home point 3 – a sizable number of patients cannot receive Gd and the development of BOLD and ASL for this group of patients is of high priority.

The detection of active inflammation in the heart is of utmost importance. This can differentiate acute ischemic injury from chronic scar, and assist in the diagnosis of active sarcoidosis, transplant rejection and myocarditis. It is felt by the vast majority of investigators that T2 weighted images can detect the area-at-risk in acute ischemia, although this has recently been disputed. Clarification of this issue will require further study with a range of T2 weighted sequences suitable for cardiac imaging. Take home point 4 – T2 weighted imaging detects edema in the heart but improved techniques with less motion and flow dependence are needed.

Numerous conditions that cause non-ischemic heart failure can result in diffuse fibrosis of the myocardium. These include hypertension, obesity, diabetes and certain chemotherapies. Antifibrotic drugs are being actively developed by the pharmaceutical industry and MR techniques to quantify fibrosis in the myocardium are thus clearly needed. The most widely used technique at present is that of extracellular volume fraction (ECV) mapping after Gd injection. Other experimental techniques currently being investigated include MR-elastography and molecular imaging with targeted Gd chelates. Take home point 5 – the ongoing development of antifibrotic drugs by the pharmaceutical industry will require techniques to measure myocardial fibrosis to be extremely accurate and sensitive. The ability of ECV mapping to detect subtle changes/regression in fibrosis will need to be studied further.

In the research arena numerous questions require further elucidation. How is the normal myocardium organized, how does it function, how do cardiomyocytes die, how can the heart be regenerated. These questions will require ongoing development in advanced techniques such as molecular imaging, spectroscopy, diffusion tractography, CEST, DENSE, elastography and others.