Assessment of Ischemia - ready for clinical routine (wall motion or adenosine first-pass perfusion)

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Myocardial perfusion and wall motion assessment by CMR for detection of CAD. Contrast media (CM) first-pass techniques are the most commonly used approaches for perfusion-CMR. Alternatively, blood oxygen level dependent (BOLD) techniques and spin-labeling techniques have also been applied to measure myocardial perfusion, but are still in an early experimental stage. As an alternative for perfusion-CMR, ischemic myocardium can also be detected directly by functional CMR during inotropic stress.

Disclosure: The author is consultant for GE Healthcare and the MR-IMPACT programme. Gd-DTPA-BMA is registered for perfusion-CMR in several European Countries, but is off-label use in the United States, other Gd-chelates are off-label use for CMR in US and Europe.

Pulse sequences for function- and perfusion-CMR. For a functional assessment steady-state free precession (ssfp) pulse sequences are the sequences of choice providing excellent SNR and robust quality. Also, the protocol of dobutamine administration can be adopted from the echocardiographic approach and excellent diagnostic performance has been achieved by this technique.

For perfusion-CMR several requirements must be met: 1) high temporal resolution of data acquisition (entire data set every 1-2 heart beats) to provide accurate signal intensity–time curves; 2) high spatial resolution in order to differentiate transmural differences in perfusion; 3) adequate cardiac coverage in order to assess extent of disease; 4) CM sensitivity in order to achieve adequate CNR (1). Currently, echo-planar or hybrid echo-planar pulse sequences (acquiring several k-lines following one single rf excitation) represent the method of choice. In order to reduce motion-induced artefacts, the acquisition windows should ideally be fitted into the cardiac cycle with minimal motion (e.g. into mid-diastole and/or into mid- to end-systole), while optimising the delay time (2). As an alternative, ssfp sequences can be used. However, they are susceptible for off-resonance and avoiding dark-band artefacts and magnetization preparation with this pulse sequence type is not trivial. Faster k-space sampling schemes exploiting spatial (multiple coils) and spatio-temporal k-space correlations (3) are currently under investigation. Any of these pulse sequences are typically combined with a 90° saturation preparation with recovery times of 100-150 ms.

T₁-shortening extravascular Gadolinium-based CM are most commonly used for MR first-pass perfusion imaging. These CM are injected as a bolus in a peripheral (antecubital) vein in dosages of 0.025 (4) to 0.15 (5,6) mmol/kg body weight at rates of 3-8 ml/sec. From single center (2) and multicenter trials (5,7), there is a trend towards better diagnostic performance at higher doses of CM for stress-only protocols. Limited data are available for invrasascular Gd-based CM for myocardial perfusion imaging. Analysis of perfusion data may involve a visual assessment (6), however, for better reproducibility and more reliable intra- and inter-patient comparisons, quantitative approaches (5) are desirable. While parameters linked to perfusion (1,2) can be easily extracted from the data, absolute quantification is much more demanding with respect to modelling (8) and its performance in multicenter trials is not available to date.

Diagnostic performance: Many single center and most recently additional multicenter, single-vendor and multivendor CMR perfusion trials demonstrated a good diagnostic performance for detection of CAD, even performing superior to SPECT (MR-IMPACT: Magnetic Resonance Imaging for Myocardial Perfusion Assessment in Coronary Artery Disease Trial). In experienced centers, perfusion-CMR can be recommended as an alternative to SPECT imaging for the detection of CAD. In patients with resting wall motion abnormalities, the combined approach of perfusion-CMR and late-enhancement CMR appears particularly attractive for a comprehensive work-up of cardiac patients.
