Sunrise Session Cardiovascular Course

Evaluation of Ischemia/Perfusion Reserve

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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.

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.

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; and 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 thus, avoiding dark-band artefacts and achieving adequate magnetization preparation with this pulse sequence type are not trivial. Faster k-space sampling schemes exploiting spatial (multiple coils) and spatio-temporal k-space correlations[3, 4] are currently under investigation. Any of these pulse sequences are typically combined with a 90º saturation preparation with recovery times of 80-150 ms.

T_1-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 0.05 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. The MR-IMPACT II then confirmed diagnostic superiority of perfusion-CMR over SPECT and gated-SPECT in a large multivendor trial involving 33 centers in Europe and US.[8] A sub-study of the MR-IMPACT II also showed diagnostic superiority of perfusion-CMR in women vs SPECT imaging for the detection of CAD. [9]

While 3T systems are able to provide higher SNR than 1.5T, currently used perfusion-CMR approaches are yielding very high performance at 1.5T [10] and thus, a comparison vs 3T did not deliver higher diagnostic performance than the 1.5T approach.[11] Limited data are available for intravascular 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 are desirable.[2, 5] While parameters linked to perfusion[2, 5] can be easily extracted from the data, absolute quantification is much more demanding with respect to modelling[12] and its performance in multicenter trials is not available to date.

Diagnostic performance - Conclusions: 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*: *M*agnetic *R*esonance *I*maging for *M*yocardial *P*erfusion *A*ssessment in *C*oronary Artery Disease *T*rial). 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.

References:

1. Schwitter, J., Myocardial perfusion. J Magn Reson Imaging, 2006. 24(5): p. 953-63.

2. Schwitter, J., D. Nanz, S. Kneifel, K. Bertschinger, M. Buchi, P.R. Knusel, B. Marincek, T.F. Luscher, and G.K. von Schulthess, Assessment of myocardial perfusion in coronary artery disease by magnetic resonance: a comparison with positron emission tomography and coronary angiography. Circulation, 2001. 103(18): p. 2230-5.

3. Kellman, P., J.A. Derbyshire, K.O. Agyeman, E.R. McVeigh, and A.E. Arai, Extended coverage first-pass perfusion imaging using slice-interleaved TSENSE. Magn Reson Med, 2004. 51(1): p. 200-4.

4. Plein, S., S. Ryf, J. Schwitter, A. Radjenovic, P. Boesiger, and S. Kozerke, Dynamic contrast-enhanced myocardial perfusion MR imaging accelerated with k-t SENSE. Magn Reson Med, 2007. 58(4): p. 777-85.

5. Giang, T., D. Nanz, R. Coulden, M. Friedrich, M. Graves, N. Al-Saadi, T. Lüscher, G. von Schulthess, and J. Schwitter, Detection of Coronary Artery Disease by Magnetic Resonance Myocardial Perfusion Imaging with Various Contrast Medium Doses: First European Multicenter Experienc. Eur Heart J, 2004. 25: p. 1657-65.

6. Wolff, S., J. Schwitter, R. Coulden, M. Friedrich, D. Bluemke, R. Biedermann, E. Martin, A. Lansky, F. Kashanian, T. Foo, P. Licato, and C. Comeau, Myocardial First-Pass Perfusion Magnetic Resonance Imaging: A Multicenter Dose-Ranging Study. Circulation, 2004. 110: p. 732-37.

7. Schwitter, J., C.M. Wacker, A.C. van Rossum, M. Lombardi, N. Al-Saadi, H. Ahlstrom, T. Dill, H.B.W. Larsson, S.D. Flamm, M. Marquardt, and L. Johansson, MR-IMPACT: Magnetic Resonance Imaging for Myocardial Perfusion Assessment in Coronary Artery Disease Trial. Comparison of perfusion Cardiac Magnetic Resonance with Single Photon Emission Computed Tomography for the Detection of Coronary Artery Disease in a Multicenter, Multivendor, Randomized Trial. Eur Heart J, 2008. 29: p. 480-489.

8. Schwitter, J., C. Wacker, N. Wilke, N. Al-Saadi, N. Hoebel, and T. Simor, MR-IMPACT II: A phase III multicenter, multivendor trial comparing perfusion cardiac magnetic resonance versus single photon emission computed tomography for the detection of coronary artery disease. Circulation, 2006. Annual Scientific Meeting of the AHA, Chicago, 2006, Abstract.

9. Schwitter, J., C. Wacker, N. Wilke, N. Al-Saadi, Sauer, Huettle, S. Schönberg, N. Hoebel, and T. Simor, MR-IMPACT II: Detection of coronary artery disease in women by perfusion-CMR: Comparison vs SPECT in a large multicenter multivendor trial. Eur Heart J, 2008. Annual Scientific Meeting, Munich, 2008, Abstract.

10. Plein, S., S. Kozerke, D. Suerder, T.F. Luescher, J.P. Greenwood, P. Boesiger, and J. Schwitter, High spatial resolution myocardial perfusion cardiac magnetic resonance for the detection of coronary artery disease. Eur Heart J, 2008: p. doi:10.1093/eurheartj/ehn297.

11. Plein, S., J. Schwitter, D. Suerder, J. Greenwood, P. Boesiger, and S. Kozerke, k-t SENSE-accelerated myocardial perfusion MR imaging at 3.0 Tesla - comparison with 1.5 Tesla. Radiology, 2008. 249: p. 493-500.

12. Schwitter, J., Myocardial Perfusion in Ischemic Heart Disease, in MRI and CT of the Cardiovascular Systeme, C.B. Higgins, de Roos, A., Editor. 2005, Lippincott Williams and Wilkins.