Quantitative Myocardial Perfusion Imaging: Comparison of SR-TurboFLASH and SR-TrueFISP at 1.5T and 3.0T

Stefan Weber[1], Inci Davulcu[1], Christoph Düber[2], Karl Friedrich Kreitner[2], and Laura Maria Schreiber[1]

[1]*Department of Radiology, Section of Medical Physics, Mainz University Medical Center, Mainz, Germany,* [2]*Department of Radiology, Mainz University Medical Center, Mainz, Germany*

Introduction

Reduced myocardial perfusion is the first effect occurring in coronary artery disease (CAD). Therefore, noninvasive assessment of myocardial perfusion using contrast-enhanced magnetic resonance imaging (MRI) has an important local value. It has shown feasibility to provide qualitative and quantitative insight into myocardial micro-circulation [1-6].

Usually, T1 weighted saturation recovery prepared pulse sequences like spoiled gradient echo sequences (SR-TurboFLASH [7]) or balanced steady-state free precision sequences (SR-TrueFISP [8]) are used to assess the first-pass of the contrast agent. The imaging time of the pulse sequences is reduced using parallel acquisition techniques [9-11].

The aim of this work was to compare the both pulse sequences SR-TurboFLASH and SR-TrueFISP for quantitative myocardial perfusion imaging at the two magnetic field strengths of 1.5T and 3.0T.

Material and Methods

A total of 20 healthy volunteers were included in the here presented study. All measurements were approved by the local Ethic Committee and written consent was obtained prior to all examinations. All volunteers underwent myocardial perfusion imaging at both field strengths using both pulse sequences in a random order for intra-individual comparison of the pulse sequences and field strengths. Measurements were performed on clinical 1.5T and 3.0T systems (Siemens Magnetom Avanto and Siemens Magnetom Trio, Siemens Medical Solutions, Erlangen, Germany). On both systems, a six-element phased-array cardiac coil was used in combination with six elements of the spine array for signal reception. In all pulse sequences, the magnetization was prepared using a non-selective saturation pulse with a saturation time TI of 100ms. The pulse sequence parameters repetition time (TR), echo time (TE), flip angle (α), and bandwidth were at 1.5T as follows: SR-TurboFLASH: 1,9ms / 1,0ms / 20° / 890Hz/Px; SR-TrueFISP: 2,2ms / 1,0ms / ~76° /1390 Hz/Px. At 3.0T the parameters were as follows: SR-TurboFLASH: 2,2ms / 1,2ms / 20° / 890Hz/Px; SR-TrueFISP: 2,2ms / 1,0ms / ~37° /1390 Hz/Px. For SR-TrueFISP, the highest possible flip angle was used for each field strength under the allowed specific absorption rate (SAR) conditions. Therefore, the flip angle of the SR-TrueFISP was highly reduced at 3.0T (~76° at 1.5T vs. ~37° at 3.0T). On both field strengths, the two pulse sequences shared the same spatial resolution with a voxel size of 2.5x2.5x8.0mm^3. GRAPPA was used in all perfusion measurements with an acceleration factor of 2 and 18 reference lines. For perfusion measurements, 3ml of Gd-DTPA were injected followed by 40ml of saline with an injection rate of 5ml/sec. 30 minutes were waited between the two perfusion measurements to avoid influence of remaining contrast agent.

For comparison of the pulse sequences and field strengths, signal-to-noise ratio (SNR) and contrast-to-noise Ratio (CNR) of the resulting signal-time-curves after segmentation of the myocardium were calculated. Furthermore, the myocardial blood flow (MBF) was calculated using the MMID4 model. All analyses were performed twice to calculate for the intra-observer variability. Therefore, the so called concordance correlation coefficient (CCC) was calculated for the results of the first and second analysis. The closer this value is to 1 the lower is the intra-observer variability.

Results

Despite the lower flip angle of the SR-TrueFISP pulse sequence at 3.0T it yielded the highest SNR and CNR values of both pulse sequences and field strengths (see figure 1 left and middle). SNR and CNR values were significantly higher with SR-TrueFISP at 3.0T compared to SR-TurboFLASH at 3.0T and 1.5T and compared to SR-TrueFISP at 1.5T ($P<0.01$ in all cases). Between SR-TrueFISP at 1.5T and SR-TurboFLASH at 3.0T no differences were found. The lowest SNR and CNR values resulted from SR-TurboFLASH at 1.5T. In absolute-quantification of the MBF, no significant differences were found between all sequences and field strengths (see figure 3 right). However, intra-observer variability was lowest with SR-TrueFISP at 3.0T. The concordance correlation coefficients were as follows: SR-TrueFISP at 3.0T = 0.90, SR-TrueFISP at 1.5T = 0.86, SR-TurboFLASH at 3.0T = 0.89, SR-TurboFLASH at 1.5T = 0.56.

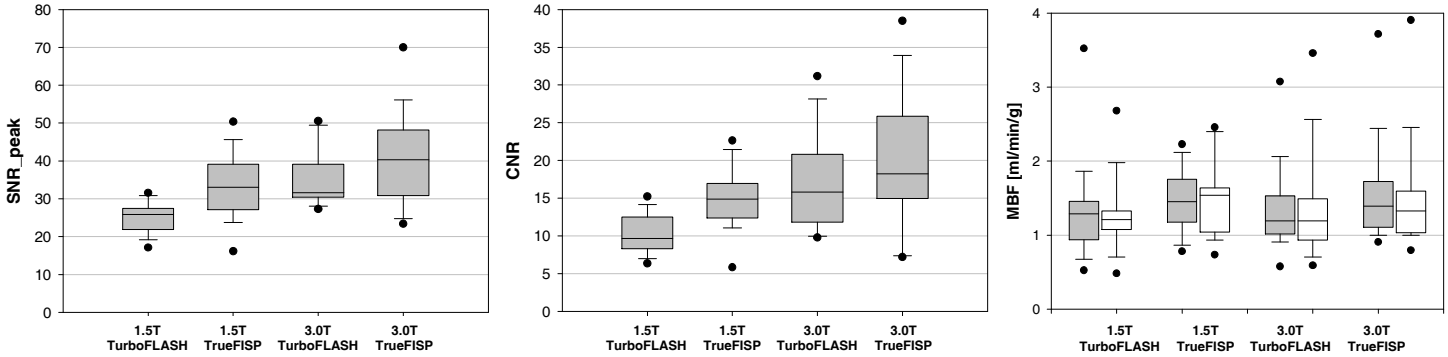

Figure 1: Comparison of the SNR (left), CNR (middle) and of the calculated MBF values (right) for SR-TurboFLASH and SR-TrueFISP at 1.5T and 3.0T.

Discussion

Results of this study show that SR-TrueFISP at 3.0T yields highest SNR and CNR values and the lowest intra-observer variability in absolute-quantification of the MBF using the MMID4 model in healthy volunteers even if the flip angle is drastically reduced in comparison to 1.5T. SR-TrueFISP is superior to SR-TurboFLASH at 1.5T and 3.0T as well as to SR-TrueFISP at 1.5T. On both field strengths, SR-TrueFISP yielded better results than SR-TurboFLASH. Therefore we conclude that SR-TrueFISP at 3.0T seems to be the best choice for quantitative myocardial perfusion imaging.

References

1. Edelman, et al. Radiology, 1994. 190(3): p. 771-7.
2. Panting, J.R., et al., J Magn Reson Imaging, 2001. 13(2): p. 192-200.
3. Schwitter, J., et al., Circulation, 2001. 103(18): p. 2230-5.
4. Schmitt, M., et al., Magn Reson Med, 2005. 53(5): p. 1223-7.
5. Jerosch-Herold, et al. Med Phys, 1998. 25(1): p. 73-84.
6. Schmitt, M., et al., Magn Reson Med, 2002. 47(4): p. 787-93.
7. Wilke, N., et al., Magn Reson Q, 1994. 10(4): p. 249-86.;
8. Schreiber, W.G., et al., J Magn Reson Imaging, 2002. 16(6): p. 641-52.
9. Kellman, P., F.H. et al., Magn Reson Med, 2001. 45(5): p. 846-52.
10. Pruessmann, K.P., et al., Magn Reson Med, 1999. 42(5): p. 952-62.
11. Griswold, M.A., et al., Magn Reson Med, 2002. 47(6): p. 1202-10.